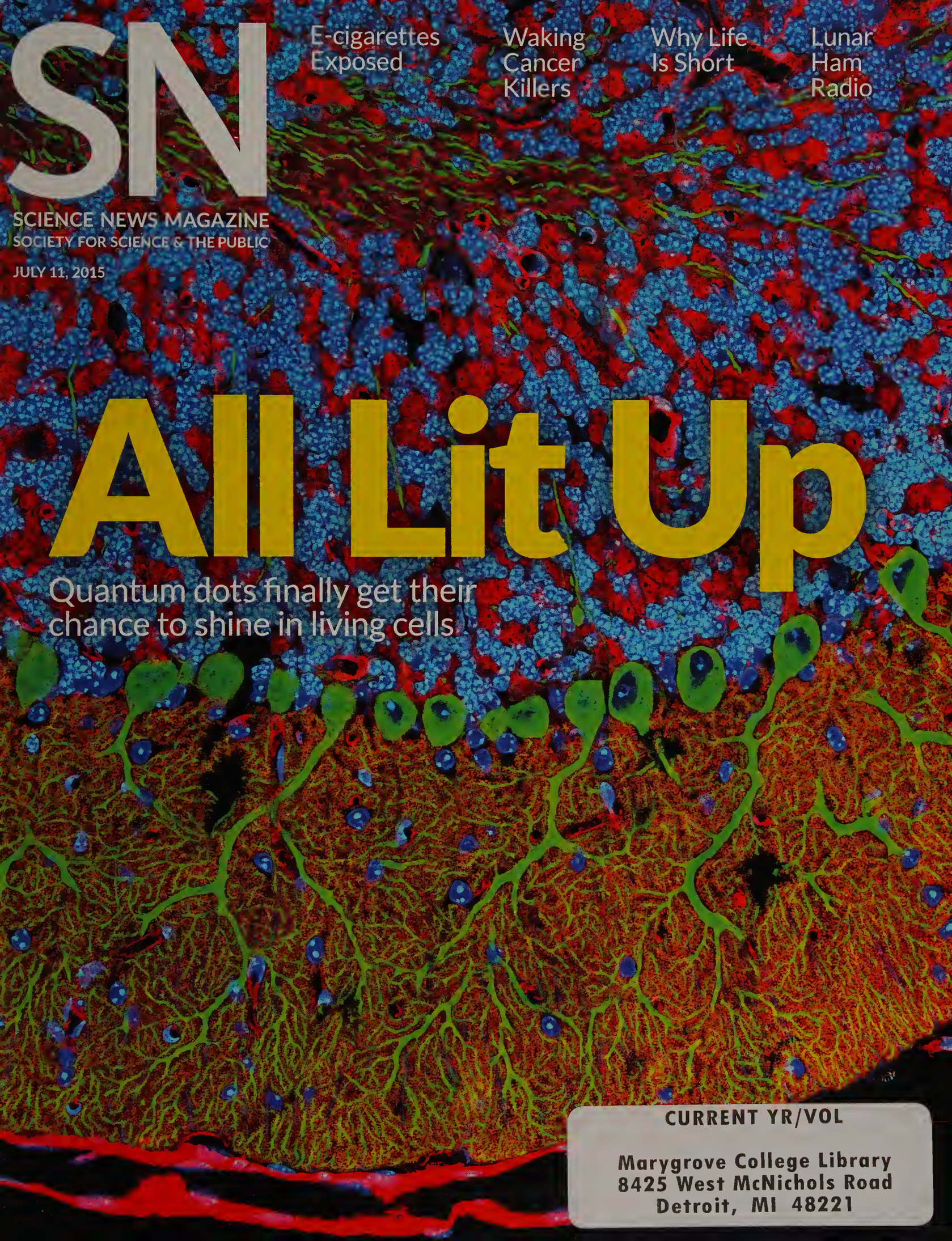
SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
JULY 11, 2015

E-cigarettes Exposed

Waking Cancer Killers

Why Life Is Short

Lunar Ham Radio



All Lit Up

Quantum dots finally get their chance to shine in living cells

Discovered: The Coin That Never Was!

America's Lost Masterpiece

The $100 Union

Original sketches found at the Smithsonian

Imagine that you were examining artifacts in the Smithsonian Institution and you found a never-seen-before sketch for the largest and highest denomination American coin ever proposed.

That's precisely what happened when a coin expert was exploring the collection at this celebrated public institution not long ago.

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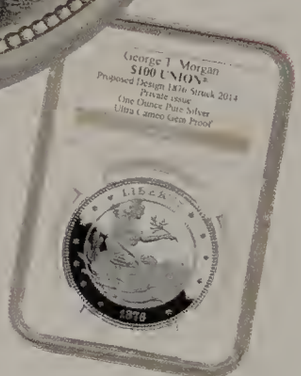

This is not a reproduction… this is the first-time ever Morgan $100 Union design struck as a silver proof.

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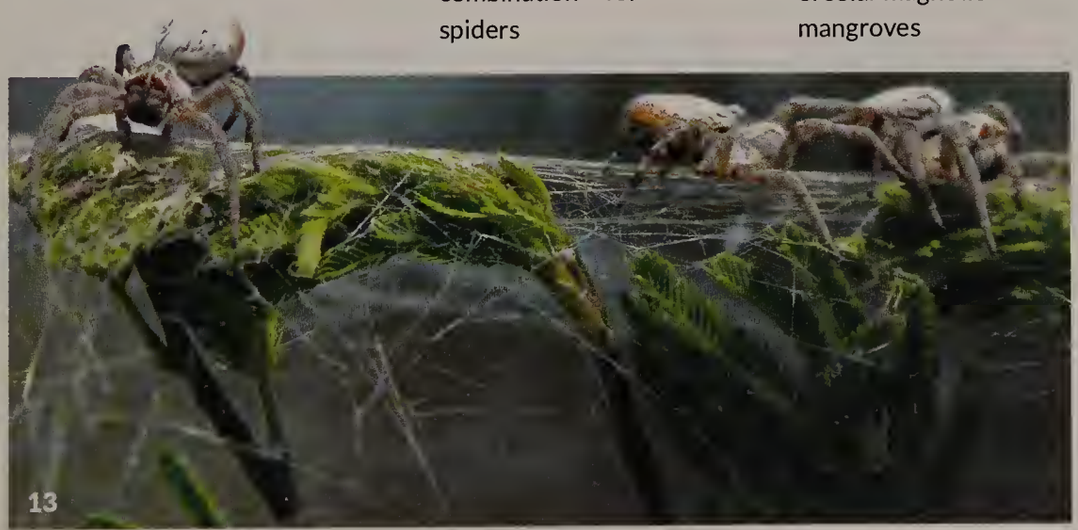
Features

News



Departments

SOCIETY UPDATE
Grant recipients selected

COVER Green quantum dots mark IP3 receptors in a mouse cerebellum. Red and blue fluorescent dyes highlight other structures. *Thomas Deerinck and Mark Ellisman/National Center for Microscopy and Imaging Research, Thermo Fisher Scientific*

E-cigarette reports provide science that society craves

For much of the last year, the most-read story on sciencenews.org was not about a faraway exoplanet or a cunning creature's adaptations to an exotic locale. It was a short report, in some ways unsurprising. In 26 different weeks since it appeared in June 2014, the story at the top of our weekly tab was Janet Raloff's article on the emerging science about the risks of e-cigarettes. It eventually garnered almost 1.2 million unique page views.

That story also ran in the magazine (*SN: 6/28/14, p. 9*), but its extended life online has impressed us. People shared the article on mobile devices, circulating it well beyond our usual science-interested crew. It's clear that people want to know about the health effects of e-cigarettes, a relatively new product that many have contended is healthier than cigarettes.

In this issue on Page 18, Raloff revisits the topic, surveying a wealth of new research about the risks e-cigarettes pose. A 37-year *Science News* veteran who now spends most of her time running *Science News for Students*, Raloff was concerned to learn that vaping has exploded among teens, who are more vulnerable to nicotine's addictive effects than adults. Her story focuses on the dangers to youth, who can legally buy e-cigarettes in some states.

E-cigarettes are advertised on TV, although in the U.S. ads for regular cigarettes are forbidden. Regulation, it seems, lags behind marketing. But that's partly because regulators need science to make sound decisions. (Although given what's known about nicotine, it doesn't seem far-fetched to assume that kids shouldn't have access to a nicotine delivery vehicle.)

The science of e-cigarettes, while new, isn't groundbreaking in the same way as other stories in this issue (see Alexandra Witze's report on Page 22 about quantum dots for biological imaging, or Nathan Seppa's roundup on Page 14 on a new class of cancer drugs). But research on e-cigarettes, along with our reporting on it, fills a crucial need in science's service to society: providing the best information available to the public, in a timely manner, so people can make wise choices. And so policymakers can use science to develop prudent guidelines for public health. It's an important kind of science that needs to be shared with a wide audience. —*Eva Emerson, Editor in Chief*

SANDY SCHAFFER

The Neptune® Bath Lift is the affordable way to regain your independence and safely stay in the home you love!

Now you can safely enter and exit your tub!

For many of us, nothing is more relaxing than a long, luxurious bath. Unfortunately, because of safety concerns, many people, particularly older people, have to forego this simple pleasure. Sure, you can spend big bucks to remodel your bathroom to provide a bathtub you can use, but who wants to do that? Now there's a better way, and it lets you use the bath that's in your home today.

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Excerpt from the July 10, 1965, issue of *Science News Letter*

50 YEARS AGO

Earth to Mars in 229 days

The longest recorded journey in the history of man will reach its goal on Wednesday, July 14 — and keep on going. The Mariner 4 spacecraft ... will have covered more than 325 million miles in order to take a few television pictures and transmit some experimental radio signals. Together, these two activities should add a great deal to man's sketchy knowledge of the planet Mars.... Despite equipment failures, meteor showers, solar flares, and perhaps even "little green men," Mariner seems to be doing just fine.

UPDATE: Mariner 4 buzzed Mars right on schedule, sending back the first up-close pictures of another planet. The grainy images showed a desiccated, moonlike surface lacking in little green men. Since that first visit, 19 additional probes have flown past, orbited or landed on the Red Planet. Even more Mars probes — 25 — have failed. More recent missions have revealed that Mars was once warm and wet. Today there are seven active missions on or above our planetary neighbor.

THE SCIENCE LIFE

The moon bouncer

If the moon is up, there's a good chance Joseph Taylor is on his ham radio, using a homemade antenna in his backyard to bounce signals off the moon's pockmarked face. It's a skill Taylor began cultivating in 2003, shortly before he retired from Princeton University. There, he had used radio waves to probe the secrets of pulsars, the spinning, magnetized neutron stars that emit bursts of radiation with clocklike regularity.

The work earned Taylor and his Princeton colleague Russell Hulse the Nobel Prize in physics in 1993, for detecting a pulsar locked in orbit with a companion (probably another neutron star). In his Nobel lecture, Taylor said that scientific goals motivated him, but so did his affinity for "a good intellectual puzzle, and the quiet satisfaction of finding a clever solution."

The same attitude has driven Taylor, 74, to spend his retirement moon bouncing. "It's possible, but it's difficult," he says. "If you succeed, it's fun." The task entails reflecting a radio signal off the moon rather than off the upper atmosphere, as regular ham users do. Taylor calls it the Mount Everest of amateur radio.

"You need to have a very sensitive receiver, the biggest antenna that you can manage and as much power as is legal," Taylor says. (People often gawk at the contraption that soars above his garage on a 70-foot-tall telescoping tower not far from the university.)

The purpose is to communicate with fellow ham users, so Taylor usually sends a broadcast appeal using the radio shorthand CQ for "seek you." He has received more than 3,000 replies — reflected off the moon — from about 900 people. It's just the latest phase of his lifelong radio hobby; Taylor got his amateur license at age 13.

When he's not moon bouncing, Taylor goes to his Princeton office and still studies pulsars. In 1974, Taylor and Hulse found the binary pulsar–neutron star system using the radio telescope at Puerto Rico's Arecibo Observatory. The cosmic tango of the pulsar and its companion provided evidence for the existence of gravitational radiation, a prediction of general relativity.

Taylor's radio hobby offers him much of the same excitement and reward as doing frontier science. Both require learning something new, he says. "So much the better if a good technical challenge is involved!"

— Julia Rosen

Radio reflections To send messages via the moon, ham radio operators send radio waves some 384,000 kilometers to the Earth's natural satellite. The waves bounce and hopefully are received by a ham radio user somewhere else.

FROM TOP: JPL-CALTECH/NASA; COURTESY OF J. TAYLOR; E. OTWELL

INTRODUCING

Tiny frogs that live on islands in the sky

Seven itty-bitty, brightly colored frog species have been found among the leaf litter in cloud forests and nearby mountains in southern Brazil. More species could be hiding on other "sky islands," researchers report June 4 in *PeerJ*.

Like other members of the genus *Brachycephalus*, the frogs are small enough to sit on a dime and are covered in colorful warnings that their skin can be tainted with neurotoxins. Because the 21 previously known species in this genus are separated by valleys and other habitats not cool or humid enough for the frogs, Luiz Ribeiro of Faculdade Dom Bosco in Curitiba, Brazil, and colleagues had a hunch that more could be found in other parts of the mountainous region.

A five-year search turned up seven species, ranging in color from a dull dark green to spotted yellow with a light blue stripe. The frogs' forests are threatened, because even when protected, they are often cleared to make room for pine farms or cattle ranches, the scientists say. —*Sarah Zielinski*

Heaps of firewood or charcoal that are as tall as they are wide make the hottest fires. Fires built tall or squat burn cooler, new calculations show.

FOR DAILY USE

Common campfire build confirmed as best

Summer vacations are upon us; one can almost smell the smoke from marshmallow-toasting campfires, bonfires on the beach, and of course classic backyard barbecues. What's even better: Those blazes may require little thought, according to a new study.

Humans tend to build very efficient fires, perhaps unwittingly, says physicist Adrian Bejan of Duke University. And he has crunched the numbers to back up that assertion.

Across cultures, countries and eras, people have built fires by piling wood or other fuel into pyramids or cone shapes. The structures tend to be about as tall as they are wide at the base, Bejan says.

Using back-of-the-envelope calculations of how air and heat flow through structures, he argues that fires with those proportions produce the hottest flames for their volume of fuel. Fires that are relatively tall or short compared with their width lose more of their heat, he says.

The calculations, appearing June 8 in *Scientific Reports*, suggest no scout handbooks are needed for leisurely summer blazes. —*Beth Mole*

SCIENCE STATS

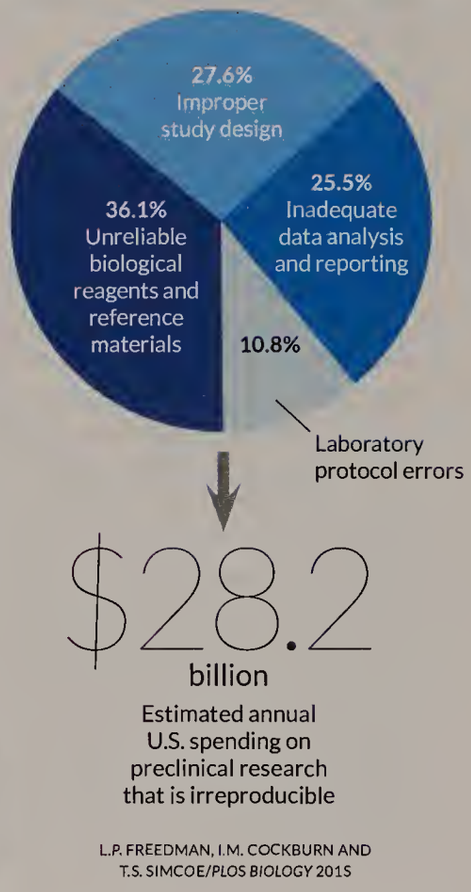
Irreproducible research is expensive

Around half of all preclinical research in the United States is not reproducible (*SN: 1/24/15, p. 20*). That failure comes with a hefty annual price tag: about $28.2 billion, concludes a review of data on irreproducibility published in the June 9 *PLOS Biology*.

Leonard Freedman of the Global Biological Standards Institute in Washington, D.C., and colleagues grouped the root causes of lack of reproducibility into four main categories. The worst offender, the team found, was faulty biological reagents and reference materials, such as contaminated or misidentified cell lines.

The researchers emphasize that it will take time and money to fix long-established flaws in the way research gets done. But the economic and health benefits could be enormous.

Problems in research add up to high costs



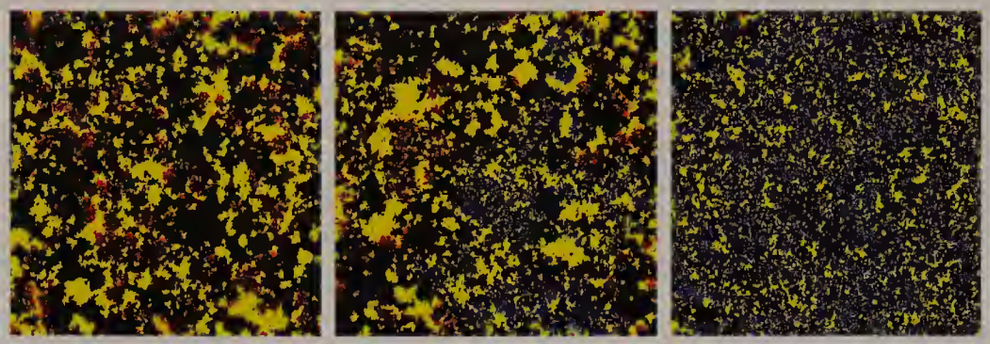
L.P. FREEDMAN, I.M. COCKBURN AND T.S. SIMCOE/*PLOS BIOLOGY* 2015

FROM TOP: L.F. RIBEIRO ET AL/*PEERJ* 2015; ERIC DUFRESNE/WIKIMEDIA COMMONS (CC BY 2.0)

LIFE & EVOLUTION

Evolution may favor limited life span

Dying prematurely could reduce competition with descendants



In a new simulation, individuals with a finite life span (blue) win out over immortals (red) as they compete for resources (yellow).

J. WERFEL, D.E. INGBER AND Y. BAR-YAM/PHYSICAL REVIEW LETTERS 2015

BY ANDREW GRANT

The disease, deterioration and death that come with age may be nature's method of population control.

Aging is a genetic mechanism that prevents humans and other organisms from living as long as they might, scientists argue in the June 12 *Physical Review Letters*. The scientists propose that age-related ailments provide the evolutionary benefit of shortening life span, which conserves resources for future generations. Scientists could greatly extend life expectancy by deactivating the machinery for aging embedded in our DNA, the researchers assert.

"I don't think it's unreasonable to think we could extend the human life span by multiples," says coauthor Yaneer Bar-Yam of the New England Complex Systems Institute in Cambridge, Mass.

The conclusion that evolution shortens life spans is based on mathematical simulations that show for the first time that relatively short-lived organisms in a population fare better over time than longer-lived and even immortal competitors.

It's an impressive result, say scientists not involved with the research, but they are skeptical that the simulations reflect reality. "It's certainly not your ordinary paper," says Carl Bergstrom, an evolutionary biologist at the University of Washington in Seattle. "I'm intrigued but cautious."

Many biologists have considered aging the result of an evolutionary trade-off: Mutations that promote reproductive success early in life can become detrimental later. Evolution does not select for truncated life spans, but an organism that avoids death from starvation, disease or other outside factors will ultimately succumb to those harmful mutations.

But past studies analyzing evolution's impact on life span tended to oversimplify, says Justin Werfel of Harvard University's Wyss Institute for Biologically Inspired Engineering. Some such studies assumed "that every place is like every other place." In reality, he says, organisms depend on the resources available where they live.

Werfel, along with Bar-Yam and Harvard bioengineer Donald Ingber, devised simulations that tracked the evolution of a population in which offspring inherit the resources left behind by previous generations. The resources came in the form of another species that served as prey. In one simulated scenario, an individual among a species of immortals, who die only from external factors such as starvation, develops a genetic mutation for mortality. In many runs of the simulation, the mortality mutation spread through the population and overtook the immortals in frequency. In an opposing scenario, a mutation for immortality within a population of mortals never took hold.

Other simulations echoed the finding that having a truncated life span — in harsher terms, dying early — provides an evolutionary advantage. Werfel says that limited life spans enabled the predators to avoid depleting the prey many generations down the line, even if there was initially plenty of food for everyone.

Michael Rose, an evolutionary biologist at the University of California, Irvine, praises the team's mathematical prowess in exploring whether longevity could pit organisms against their descendants in a battle for resources. But he says that humans and many other creatures can easily move and obtain new resources. He says the simulations may accurately describe a tree that drops seeds directly beneath it, forcing the tree to compete directly with its offspring. (Werfel says simulations that allowed the predators to move around produced the same results.) Rose also points out that many creatures, including humans before the era of modern medicine, are often killed by predators, weather or disease long before they suffer from the effects of aging.

Bar-Yam says he is confident that shortened life spans are ubiquitous in nature, including in humans. If people are programmed to die, he says, then scientists should focus on discovering and deactivating the genetic mechanism. "Instead of treating age-related diseases, we can address them by intervening in the process of aging," he says.

Bergstrom isn't as optimistic. Even if the new study is right about aging's primary role, the trade-off mechanism for aging could also be at work. And Valter Longo, who studies aging at the University of Southern California, says it's not clear how long we would live even if evolution didn't kill us off. A profit-hungry car company could design a vehicle to break down after a certain amount of time, he says. "But if it doesn't do that, it doesn't mean the car will last forever."

Bar-Yam says he welcomes positive and negative feedback. "We expect this to be controversial," he says. "I hope we end up shaking things up quite a bit." ■

MATTER & ENERGY

Rogue waves may have warning sign

Analyses find signals that precede some mystery swells

BY ANDREW GRANT

Sailors have long told remarkable stories of monstrous, ship-damaging waves that seem to come out of nowhere. But new research analyzing "rogue waves" reveals that at least some of them are foreseeable.

A telltale set of conditions precedes the appearance of bright flashes in tabletop laser experiments that are analogous to rogue water waves, researchers report in the May 29 *Physical Review Letters*. The results suggest that multiple processes, some predictable, can lead to these extreme events. "People in the field have been waiting for something like this to be done," says Mattias Marklund, a theoretical physicist at Chalmers University of Technology in Gothenburg, Sweden.

Rogue waves were once considered less scientific curiosity than nautical legend. But in 1995, a gas platform in the North Sea recorded a sudden wave that towered about 26 meters. Scientists thought a steep wave with that height should materialize only every 1,000 to 10,000 years.

Later research showed that rogue waves occur far more often. They crop up because of interactions that enable small perturbations to rapidly grow into behemoth swells. In 2007, UCLA physicist Daniel Solli and colleagues discovered an analogous phenomenon when laser pulses fired into a fiber produced anomalously bright flashes on the other end (*SN: 12/15/07, p. 374*).

Optical physicist Günter Steinmeyer of the Max Born Institute in Berlin and colleagues obtained data from Solli and from the North Sea platform, and also reviewed data from an experiment of their own in which they measured the brightness of laser light exiting a container of gas.

For all three datasets, the researchers performed an analysis to determine whether the distribution of heights (or for light, brightness) of the waves was random. The wave measurements in Solli's fiber data were indeed random, which makes the prediction of rogue waves impossible. But discernible patterns showed up in the ocean and gas data.

The researchers discovered that a milliseconds-long period of relative calm in the gas data often foretold the emergence of an extreme wave. Rogue water waves also should be predictable, Steinmeyer's team concluded, because of their similar turbulent underpinnings. Marklund says the gas could be a useful analog for scientists who have little data on genuine rogue ocean waves. ■

HUMANS & SOCIETY

Human face laugh lines traced to apes

Chimps' expressions signal silent communication evolved early

BY BRUCE BOWER

Laughter's evolutionary story may be written on chimpanzees' faces.

Chimps at play make open-mouth facial expressions while either laughing out loud or staying silent, say psychologist Marina Davila-Ross of the University of Portsmouth in England and colleagues. These results suggest that a nonhuman primate's facial expressions can communicate without making a sound, the researchers report June 10 in *PLOS ONE*.

Muscle motions in chimps' laughing faces resemble those of humans. People's mirthful expressions, sometimes paired with laughter, evolved from a simpler link between open-mouthed expressions and laughter in ape ancestors of humans and chimps, Davila-Ross' team proposes.

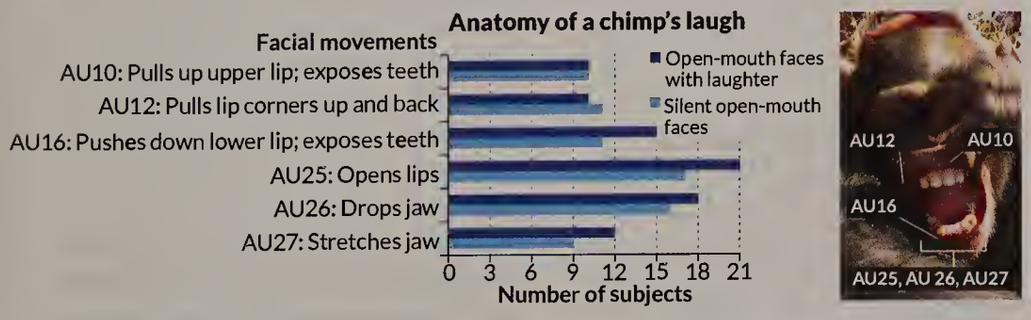
"Our study provides evidence that chimps can communicate during play in versatile ways with open-mouth expressions that have the same evolutionary origin as human laugh faces," she says.

Researchers knew that chimps and other apes produce their own brand of laughing when playing or being tickled. Humans laugh when exhaling, typically producing a "ha ha" or "he he" sound. Lacking that degree of breath control, chimps laugh while exhaling and inhaling, resulting in a loud panting sound.

Neuroscientist Robert Provine of the University of Maryland, Baltimore County has long suspected that human laughter evolved from labored breathing during rough-and-tumble play of a common ancestor of people and chimps. "What's novel in the new study is that chimps' facial expressions have been linked with their laughter," Provine says.

Chimps laugh during play; people laugh mostly during conversations. It's unclear, Provine says, whether chimps' silent open-mouth faces are reactions to being stimulated in a social setting.

The ability to produce facial expressions while silent expands the potential range of social communication, Davila-Ross says. Humans have greatly elaborated on an ancient facility for nonverbal facial communication, she suspects. ■



Laugh it up A chimp displays one set of facial-muscle movements used for open-mouth expressions. Each of those movements, with or without laughing, appeared in varying numbers of chimps at play in an observational study.

M. DAVILA-ROSS ET AL/PLOS ONE (CC BY 4.0)

HUMANS & SOCIETY

Trackers decipher ancient footprints

Hunters help reconstruct behavior of early Europeans

BY BRUCE BOWER

Three African hunters and animal trackers have cornered an especially elusive prey — long-gone Stone Age people who left footprints in some of western Europe's decorated caves.

Frustrated by the inability of footprint measurements to reveal ancient human activities in the caves, a team led by Andreas Pastoors of the Neanderthal Museum in Mettmann, Germany, called in a trio of Namibian Ju/'hoan San men who hunt together. Aside from tracking a range of animals, these men belong to a community where everyone learns to distinguish footprints of family and friends.

During visits to four French caves in 2013, the trackers offered new takes on behaviors reflected in ancient human foot impressions, Pastoors and colleagues report online May 6 in the *Cambridge Archaeological Journal*. Artifacts previously found in the caves belong to the Magdalenian culture, which dates to between 17,000 and 12,000 years ago.

Two Namibian animal trackers crouch behind a barrier in France's Niaux cave system to examine and interpret human footprints dating to sometime between 17,000 and 12,000 years ago.

Some of the most intriguing observations were made inside Tuc d'Audoubert Cave. In an inner chamber, the trackers concluded that a man and a teenage boy had each hauled two loads of clay scooped out of a pit to an adjacent space. Foot impressions going away from the pit are deeper than those going back, consistent with two people having carried heavy loads to the nearby room, the trackers pointed out. A broken stalactite in the pit may have been used as a shovel.

Someone expertly sculpted two clay bison in the chamber next to the clay pit. No footprints are preserved on the floor surrounding the sculptures.

Pastoors' group estimates that at least 90 kilograms of clay was removed from the pit. That total closely matches the amount of clay used to create the two bison.

Oddly, footprints running to and from the clay pit indicate that whoever was there walked on their heels. Researchers have puzzled over those heel marks since they were discovered in 1912. One investigator suggested in 1928 that several young people had held a ritual dance in the cave.

The trackers disagreed. Heel walking guaranteed that no one would recognize the footprints of the man and the boy, the trackers proposed. An act of powerful symbolism, such as sculpting bison that probably had important ritual significance for their makers, may have demanded that those involved stay anonymous, Pastoors and his colleagues suspect.

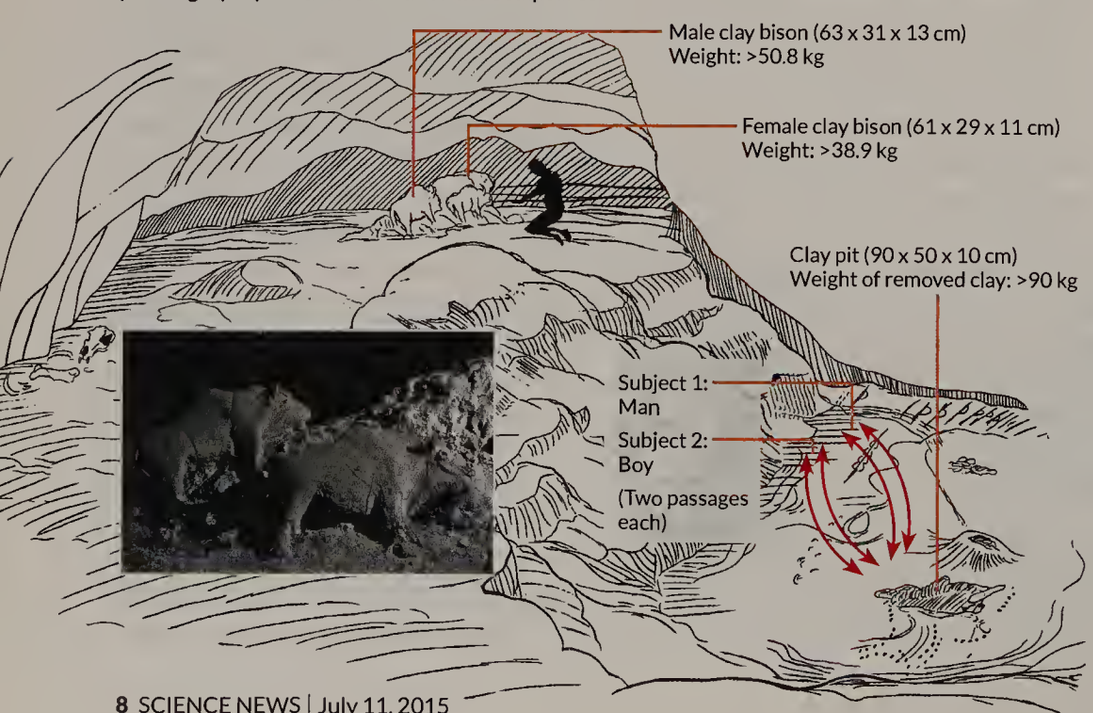
"This is the first time we've gotten even a slight insight into how an ancient piece of art was produced," says study coauthor Tilman Lenssen-Erz of the University of Cologne in Germany.

The trackers also identified seven previously unnoticed knee imprints near the pit. Those impressions lie close to lines drawn with fingers in the clay floor, apparently by the Stone Age man and boy while kneeling.

In the nearby Fontanet Cave — which has attracted little research since the discovery of footprints there in 1972 — the trackers determined that a footprint previously suspected to have been made by someone wearing moccasins was actually made by a barefoot man. Partial marks remained from all five toes. Footprints of three more males were identified in the same area. Among nearly two dozen footprints located nearby, the trackers identified impressions of six men, two women, one boy, three girls and a male of uncertain age.

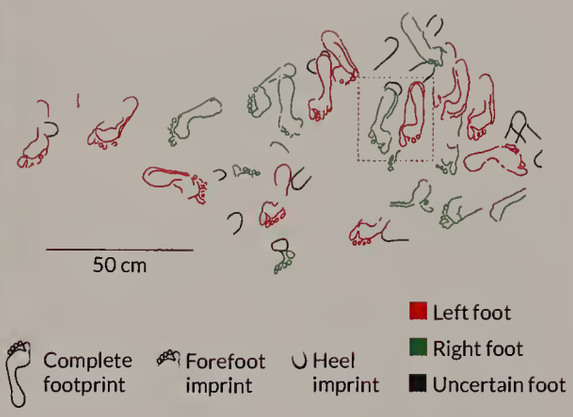
At Pech Merle Cave, the site of famous spotted horse paintings and a set of footprints discovered in 1922, the trackers noticed six more foot impressions. In their view, two men, two women and a

Big haul At France's Tuc d'Audoubert Cave, Namibian trackers interpreted footprints near a clay pit (lower right) as those of a man and a boy who each carried two loads of clay into a chamber where clay bison were sculpted (inset). The estimated amount of clay taken from the pit roughly equaled that used for the sculptures.



FROM TOP: TRACKING IN CAVES, ASSOCIATION LOUIS BÉGOUËN; ASSOCIATION LOUIS BÉGOUËN, ADAPTED BY S. EGTS

Ancient walkway
Stone Age footprints in the Niaux cave system in France were made by a girl who walked across a low-ceilinged area, African trackers concluded in an unusual project organized by archaeologists. The drawing depicts complete and partial footprints shown in the image.



boy made the prints while walking about 100 meters inside the cave.

Finally, the trackers read 38 previously discovered footprints at the Niaux cave system as those of a girl who strode across an area with a low ceiling. The girl stood just under 1 meter tall, Pastoors' group estimates.

Of at least 24 individuals that the trackers identified from footprints in the four caves, 10 were children or teenagers. That number is too small to support previous speculation that Stone Age kids were the most frequent visitors to painted caves, Lenssen-Erz says.

Researchers who have studied ancient human footprints have mixed reactions to bringing in trackers from hunter-gatherer groups to interpret these finds.

Archaeologist Nick Ashton of the British Museum in London led a team that discovered footprints of at least five prehuman individuals from more than 780,000 years ago (*SN: 3/22/14, p. 14*). Those impressions were briefly exposed along England's coast before being washed away by the tides.

"In an ideal situation, it would have been informative to get the interpretation of modern trackers," Ashton says. But hunter-gatherers today have no experience tracking hominids whose footprints reflected distinctive body builds, Ashton cautions.

Namibian trackers don't have relevant experience for determining the sizes and ages of ancient human footprint makers in Europe, contends geologist Matthew Bennett of Bournemouth University in Poole, England. Probable differences in body build and mass between today's Ju/'hoan San and ancient visitors to French caves raise doubts about the trackers' ability to read Stone Age footprints accurately, Bennett says.

But experienced trackers can help researchers interpret ancient footprints, says anthropologist Steve Webb of Bond University in Robina, Australia. Four trackers from an aboriginal group called the Pintubi helped Webb's team interpret 20,000-year-old human footprints discovered in southeastern Australia (*SN: 1/7/06, p. 3*).

Among their contributions, Pintubi trackers confirmed the presence of footprints made by a one-legged man who had hopped along using a stick for support — much as a one-legged hunter in their own community did. ■

IMAGE: HEINRICH WENDEL, DRAWING: L. PALES, A. PASTOORS ET AL/CAMBRIDGE ARCHAEOLOGICAL JOURNAL 2015

BODY & BRAIN

Female's nose can block male odors

During infertile periods, mice are oblivious to possible mates

BY LAURA SANDERS

Under certain conditions, a female mouse's nose turns a blind eye to the scent of a male. On infertile days, odor-sensing nose neurons fail to alert the brain to the presence of a potential mate, scientists report in the June 4 *Cell*.

The results offer a surprising instance of the nose controlling behavior, not the brain, says coauthor Lisa Stowers of the Scripps Research Institute in La Jolla, Calif. "This was the craziest thing ever to me," she says. "Sensory systems are supposed to just gather as much information as possible and pass it on to the brain." But here, the nose is acting as an information gatekeeper. If our eyes behaved like this, it would be as if after a big meal, a person was literally blind to the sight of food, Stowers says.

Stowers and colleagues studied female mice at different stages of their ovulation cycles. The team wanted to know why females are indifferent to males during the infertile period known as diestrus.

"We expected to be looking in the brain," Stowers says. But the team's experiments led to the nose instead. Odor-sensing nerve cells in a nose structure called the vomeronasal organ recognize the odor of male mice and alert the brain. But the message doesn't seem to transmit during diestrus, when levels of the hormone progesterone are high. Progesterone kicks off a chain of molecular events that leaves these cells blind to the odor, the researchers found. Other nerve cells in the vomeronasal organ still recognize cat odor in the presence of progesterone, so the sensory shutdown seems specific to the male-mouse scent.

"In this case, it really looks like the first cells in the olfactory pathway decide not to transmit the information that is there," says neuroscientist Ivan Manzini of the University of Göttingen in Germany. "That is something special." ■

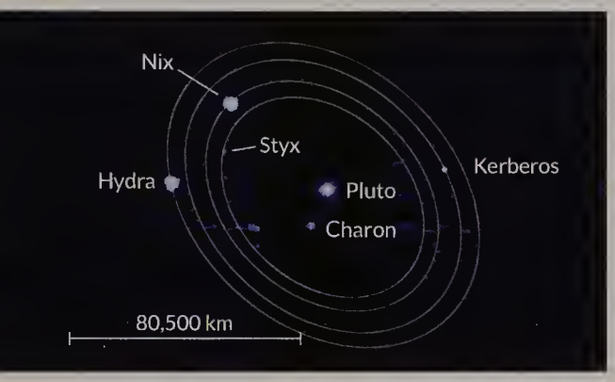
ATOM & COSMOS

Pluto's moons probably born in crash

One satellite may be remnant of rock that hit the dwarf planet

BY CHRISTOPHER CROCKETT

Of Pluto's five moons, four — Styx, Nix, Kerberos and Hydra — are packed about as tightly together as possible, researchers report in the June 4 *Nature*. The four orbits, plus that of the largest moon, Charon, are nearly synced, suggesting that the family formed from debris left behind after something big slammed into Pluto.



Pluto's moons are tightly packed in nearly synced orbits, suggesting that they formed in the aftermath of a collision.

Pluto's moons keep returning to nearly the same configuration, the researchers found. Charon completes three orbits, for example, in roughly the same time Styx loops around once. Since it's unlikely that the moons became synced by chance, they probably have a common origin. The tight spacing also suggests that no other moons or rings lurk among the four smallest moons, since most debris would get snatched by one of the satellites.

"Think of it as archaeology," says Mark Showalter of the SETI Institute in Mountain View, Calif. The properties of the moons hint at how they formed. Showalter and Douglas Hamilton of the University of Maryland in College Park studied the moons using Hubble Space Telescope images that span seven years.

"The small satellites should have very similar surfaces," says Marc Buie, a planetary scientist at the Southwest Research Institute in Boulder, Colo. But Kerberos appears much darker than its siblings. Kerberos may be part of the body that hit Pluto, Showalter says. The other moons may be remnants of Pluto itself.

At least two of the small moons tumble unpredictably along their orbits as they are nudged by Charon and Pluto. "On Nix, you wouldn't know if the sun was coming up tomorrow," says Showalter. The sun might rise in the east one day and come up in the north the next, if it rose at all.

Even better views of the moons should come soon, Buie says, when the New Horizons spacecraft flies by Pluto on July 14 (*SN: 6/27/15, p. 16*). ■

EARTH & ENVIRONMENT

How injection wells start quakes

Fluid disposal initiates slow slip, indirectly causes tremors

BY THOMAS SUMNER

The first up-close look at artificially triggered tremors suggests seismicity caused by human activities starts slow before shaking things up. The finding could help scientists better understand, and possibly even stem, the rising rate of earthquakes near sites where unwanted fluids, such as gunky water left over from fracking, are injected underground.

Scientists triggered earthquakes along a fault that runs beneath a repurposed Cold War–era military base. As pumped-in water pressurized the rock, the fault slowly slid without causing seismic activity. After a while, this slipping spawned earthquakes away from the injection site, suggesting that the quakes were an indirect effect of the fluid injection, the researchers report in the June 12 *Science*.

If the slow sliding could be monitored, the fluid injection rate could possibly be tweaked to avoid earthquakes, geophysicist François Cornet writes in an accompanying commentary. "If you could detect this nonseismic slip, then you can reduce or completely stop your fluid injection without getting a significant seismic event," says Cornet, of the University of Strasbourg in France. "But if you just pump like crazy, the slip will keep going and you'll get some seismic events."

Earth's depths have become a popular place to stash watery waste such as used fracking fluid. While most quakes linked to injection wells are imperceptible without a seismometer, a growing number are intense enough to rattle the surface. The rate of magnitude 3 or stronger quakes in north central Oklahoma, for instance, has recently increased nearly 300-fold (*SN: 8/9/14, p. 13*). Scientists worry that injection wells could trigger even larger quakes, but don't have a handle on the physical processes that lead from fluid injection to ground shaking.

Yves Guglielmi of Aix-Marseille University in France and colleagues went underground to track induced tremors. A belowground facility in France sits over a roughly 500-meter-long fault where two rocky slabs grind against each other. The team drilled down to a depth of 282 meters into the boundary between the fault's two sides and pumped in 950 liters of water.

As the water pressure in the fault grew, the fault slowly slipped about four-millionths of a meter per second without producing seismicity. About 18 minutes into the experiment, earthquakes rumbled. Most of the roughly 80 induced microquakes began at least a few meters away from the injection site, where the pumped-in water hadn't reached.

The slow slip, not the water, was directly responsible for the quakes, says Guglielmi. As the water pressure rose, it probably slackened the forces that squeeze the two sides of the fault together. As the freed segment of the fault slid, the bookends of the fault — which were not exposed to the injected water — probably became strained. Eventually, the stress became too much and triggered the quakes, Guglielmi says. ■

NASA, ESA, L. FRATTARE/STSCI

GENES & CELLS

Protein variant guards against prions

Natural selection yields cure for fatal, infectious brain disease

BY TINA HESMAN SAEY

Ending cannibalism stopped a deadly brain-wasting disease called kuru. But evolution had already devised a cure for the prion disease, a new study shows.

Some of the Fore people of Papua New Guinea have a variant of a brain protein that prevents kuru and related diseases, researchers report online June 10 in *Nature*. "We've never seen anything before that is completely protective," says coauthor John Collinge, a neurologist at University College London.

Understanding how the variant protects against prion diseases may give new insights into Alzheimer's, Parkinson's and other diseases caused by twisted forms of normal brain proteins, he says.

Kuru results when a brain protein called PrP gets twisted into a disease-causing, or prion, form. The rogue protein then corrupts other normal proteins. The twisted proteins clump together and kill brain cells.

Other prion diseases include bovine spongiform encephalopathy (mad cow disease) in cattle and Creutzfeldt-Jakob disease in humans. People may contract variant Creutzfeldt-Jakob disease, or vCJD, from eating beef tainted with mad cow disease.

Kuru first appeared in the 1890s. It spread when Fore women and children ate kin during funeral rituals. By the 1950s, kuru claimed about 2 percent of the population annually in each village. Ritual cannibalism ended in the late 1950s after intervention by the Australian government and kuru cases dwindled, says anthropologist Shirley Lindenbaum of City University of New York.

Natural selection was already at work to end kuru. Sometime in the past, Fore ancestors had developed a genetic variant that changes the 127th amino acid in the chain that makes up the PrP protein from glycine to valine, a change known as V127. Collinge and colleagues had previously found the variant in Fore people who had lived in kuru epidemic areas but did not get the disease.

In the new study, Collinge and colleagues genetically engineered mice to make human versions of PrP in their brains. Some mice made normal PrP, others made both normal PrP and V127, and some made only V127.

Mice with only the protective variant didn't get prion diseases, including vCJD, when injected with prions. About 10 percent of mice with both normal PrP and V127 developed vCJD symptoms but didn't die of the disease.

The results indicate that V127 not only resists being corrupted but also somehow protects the normal form of the protein, Glenn Telling, a prion researcher at Colorado State University in Fort Collins, writes in an accompanying commentary.

If cannibalism had continued among the Fore, V127 may have eventually stopped the kuru epidemic; anyone who didn't have protective variants would have been wiped out by the disease, Collinge says. Those immune to kuru could have repopulated the villages. ■

BODY & BRAIN

Alzheimer's spares music memories

Disease may not harm brain areas linked to song familiarity

BY LAURA SANDERS

Brain areas that respond to music seem to withstand the ravages of Alzheimer's disease. These neural bastions, described June 3 in *Brain*, may help explain why music can sometimes move people suffering from advanced dementia.

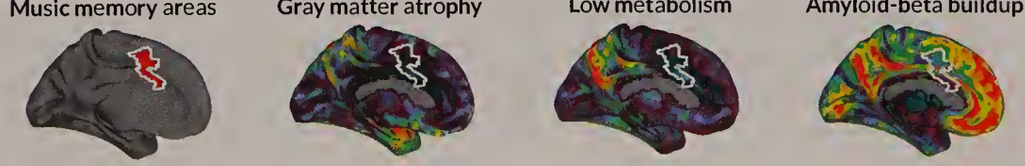
Scientists began their study after noticing that music had a special influence on their family members with Alzheimer's. Jörn-Henrik Jacobsen, now at the University of Amsterdam, and colleagues looked for brain areas involved in responding to songs that a person has known for a long time. Healthy volunteers listened to snippets of familiar songs, songs they had recently heard for the first time and songs they had never heard before while undergoing a functional MRI scan. The scans identified two adjacent brain areas that seem to respond to familiar songs: the caudal anterior cingulate and the ventral pre-supplementary motor area.

Next, 20 elderly people with Alzheimer's underwent brain scans that looked for brain thinning, low metabolism and deposits of amyloid-beta, a sticky protein linked to Alzheimer's.

Unlike most other brain areas, the music-related areas didn't show much thinning or big declines in metabolism. A-beta, however, was present, consistent with the idea that the protein is an early marker for the disease.

The results are valuable, says psychologist Mohamad El Haj of University of Lille 3 in France. El Haj and colleagues reported May 28 in *International Psychogeriatrics* that familiar music seems to boost autobiographical memories in people with Alzheimer's. Perhaps music, especially songs from when a person was young, serves as a lifeline that, once summoned, can bring up other aspects of a person's life, Jacobsen says. ■

Music memories In people with Alzheimer's disease, two adjacent brain areas (in red, far left) that seem to be involved in recognizing familiar music showed relatively less gray matter thinning and higher metabolism than other brain regions. These areas still had substantial amyloid-beta buildup. Redder colors are a sign of more advanced disease.



J.-H. JACOBSEN ET AL/BRAIN 2015

GENES & CELLS

Most DNA tags cut from germ cells

Some epigenetic markers survive, might pass on disease risks

BY MEGHAN ROSEN

Mom and dad's lifestyle may leave less of a mark on future generations than scientists have suspected.

In the first weeks after conception, some cells in human embryos get their genetic blueprints scrubbed clean, conclude three new studies in the June 4 *Cell*. Those cells, which become sperm or eggs, could beget the embryos' future offspring.

The genetic scrub erases notes that environmental factors write on parents' DNA, so that a child's sperm or eggs start with a clean slate — mostly. One study revealed that a few spots in the complete set of DNA blueprints avoided the cleanse. So some of the DNA notes that people rack up during their lives may pass from generation to generation, possibly transmitting risk for diseases such as schizophrenia far down the family tree (*SN: 4/6/13, p. 18*).

"But by and large, this paper says that's very unlikely," says epigeneticist Rob Martienssen of Cold Spring Harbor Laboratory in New York.

In the last two decades or so, scientists have begun to understand how these notes work. Chemical, or epigenetic, tags decorate DNA, and like pencil notes scrawled atop blueprints, these tags carry extra information. They modify a cell's building plans — by telling which genes to switch on or off — without actually changing the DNA.

What people eat, what they breathe and how much they exercise can all influence their assortment and number of chemical tags, such as methyl groups.

Some scientists have suggested that these methyl tags might be inherited along with DNA passed from parent to child. Research has shown that babies born to obese fathers carry a different set of tags than kids of normal-weight dads.

But the evidence that parents' lifestyles affect more than the following generation or two is still fuzzy, says Azim Surani of the University of Cambridge.

And the idea that people pass down epigenetic information for multiple generations doesn't jibe with mouse studies. In mice, germ cells, which give rise to sperm and eggs, undergo a thorough cleaning: Most chemical tags get erased.

But no one had looked at human germ cells. Surani and two other groups separated germ cells from the other cells that make up 4- to 19-week-old human embryos. The teams mapped the germ cells' DNA tags and the genes at work.

The tags on germ cells' DNA mostly got swept away. Of the tags that Surani's team studied, only about 4 percent stuck around, compared with some 37 percent in a different kind of embryonic cell.

The results suggest that germ cells have developed a strong system for ensuring that epigenetic information doesn't sneak through to subsequent generations. Still, not every tag was erased. Of the remaining tags, some marked spots in the genome linked to schizophrenia, obesity and multiple sclerosis.

"It's potentially provocative," says epigeneticist Wolf Reik of the Babraham Institute near Cambridge, England. Because the erasure is incomplete, some DNA tags could still travel down multiple generations, he says. ■

HUMANS & SOCIETY

Bronze Age people were on the move

Major migrations recorded in DNA of ancient Eurasians

BY SARAH SCHWARTZ

Bronze Age people were big travelers, but probably not so fond of dairy.

A large-scale study of ancient genetics, published in the June 11 *Nature*, provides evidence for migrations and lactose intolerance in Bronze Age Eurasia.

The Bronze Age, about 3,000 to 5,000 years ago, was a time of big cultural changes, says Morten Allentoft of the Natural History Museum of Denmark. Scientists have argued about whether those changes came from the spread of ideas or the physical migration of people.

Allentoft's team analyzed DNA from 101 Bronze Age human samples, mostly teeth, from Europe and Asia.

Allentoft says the most important finding is that the transition to the Bronze Age "involved large-scale human migrations." For instance, the study provides new evidence for eastward migration, says Harvard geneticist David Reich. The Yamnaya culture, a population of herders that originated around 5,000 years ago in what is now southwest Russia, is genetically indistinguishable from the slightly younger Afanasievo culture, which lived thousands of kilometers farther east.

Only about 10 percent of Bronze Age Europeans could digest lactose, the study suggests. This is surprisingly low, Allentoft says, since these people had cattle. The frequency of the single genetic change associated with lactose tolerance must have increased dramatically after the Bronze Age, he says, since tolerance is widespread in Europe today.

Large-scale genetic studies like this one could shed light on other eras, before and after the Bronze Age, Allentoft says. ■

During the Bronze Age, the Yamnaya culture migrated north, west and east from eastern Europe, introducing customs and genes to the younger Corded Ware and Afanasievo cultures.

M. E. ALLENTOFT *ET AL*/*NATURE* 2015

In colonies of velvet spiders (shown), one daring individual with bad information leads to disaster.

BERNARD DUPONT/FLICKR (CC BY-SA 2.0)

LIFE & EVOLUTION

Bold, incorrect spiders mislead groups

Wrongheaded notions prove dangerous to a colony's health

BY SUSAN MILIUS

The wrongheaded notions of an influential individual can make a group sluggish in learning from its mistakes, even among spiders.

Velvet spiders (*Stegodyphus dumicola*) with bold behavior but incorrect information were bad influences on their colonies, researchers reported June 11. Spider growth faltered in these colonies because naïve group mates were slow to catch on to bold ones' errors. In contrast, misinformed shier spiders didn't undermine their colonies' prospects.

The bold idiots can be considered "keystone individuals," says study coauthor Jonathan Pruitt of the University of Pittsburgh. Other research has documented the existence of disproportionately influential individuals for good or ill in various species. Older female elephants lead their herds; superspreader humans transmit diseases to a large number of people. Yet, Pruitt says, he knows of no previous experiment on social groups seeded with individuals deliberately taught information that later turned wrong.

Pruitt and Noa Pinter-Wollman of the University of California, San Diego developed an experiment to mimic spider splinter groups that venture away from their original colony to start a new one. That allowed researchers to study the interplay of personality and information.

Pruitt and colleagues tested spiders for boldness by puffing air at them, a disturbance that prompts them to feign death. Spiders that quickly resurrected were ranked as bolder. Researchers then trained some bold spiders, as well as some shier ones, to associate a pattern of web quivering (created by a vibrator) with a tidbit of moth meat. A different vibration indicated a deadly ant was nearby.

The researchers created colonies with one bold spider and nine others, including one in each colony (either a bold one or a generic one) trained on the vibrations. To create misinformation for some of the new colonies, researchers switched vibration cues so the trained spider huddling in the group's nest refuge did exactly the wrong thing. Picking up vibes that used to mean food, the educated individual would leave the refuge to climb the web only to find a deadly ant. And when the web jiggled as it had for ants, the experienced spider did not rush out.

A knowledgeable bold spider did not offer a huge advantage over a knowledgeable shy one. But colonies with a bold, wrong spider struggled, taking extra trials to learn to hesitate before dashing out at the old lunchtime cue.

Daniel Rubenstein of Princeton University, who studies animal decision making, wonders whether bolder individuals in the real world would be more likely to be misinformed than anyone else. He's also curious about how the stage of a group's development affects the kinds of personalities that benefit or harm it. ■

MEETING NOTES

Why caterpillars whistle

A caterpillar that emits a squeaky whistle may be mimicking bird calls warning of a deadly threat. If so, the walnut sphinx caterpillar (*Amorpha juglandis*) is the first invertebrate known to make phony alarm calls, Jessica Lindsay of the University of Montana in Missoula reported June 12. Broadcasting recordings of some of the moth caterpillars' whistles can send some birds fleeing for cover. The birds react as if they have heard the high-pitched "seet" that many species emit when a hawk looms near, Lindsay said. The main component of one caterpillar whistle is a little swoop in the same frequency range as a chickadee seet. Like other animals, the caterpillars whistle in a crisis. When birds peck at them, the caterpillars clench their bodies to blow air out of two of their breathing holes on their sides, researchers at Carleton University in Ottawa reported in 2011. — *Susan Milius*

How mantis shrimps spar

Mantis shrimps famed for their murderously fast punches readily swing at each other during disagreements. In about a third of 34 disputes over lab territory, a *Neogonodactylus bredini* mantis shrimp's first move was to slam a raptorial club into a rival, Patrick Green of Duke University reported June 11. All but one of the rest of the clashes eventually came to blows. Based on face-offs among other animals such as deer, Green and Sheila Patek predicted that mantis shrimps would start combat with harmless displays giving opponents a chance to assess each other. Instead, mantis shrimp punches allow for nonfatal assessment. A punched animal curls its rear forward under its legs so the last body segment rises in front of the animal like a bumpy shield. The winner of sparring rounds is often the combatant delivering the most blows, Green found. — *Susan Milius*

BODY & BRAIN

New cancer drugs can wake up sleeping killer T cells

Frontline immune system fighters, often evaded by tumors, might now resume the attack

BY NATHAN SEPPA

Cancer relies on a bag of tricks that can render it virtually invisible to the body's disease-fighting apparatus. Tumors even co-opt "checkpoint" proteins found on the immune system's T cells. These proteins normally prevent the immune system from running amok. When activated, these checkpoints can turn a T cell from a bristling warrior ready for a fight into a dozing sentinel — and cancer takes full advantage.

Now, though, new drugs that disable these checkpoint proteins are showing a keen ability to awaken T cells and, in so doing, pull away cancer's veil. In the last year, studies testing a handful of these drugs have demonstrated eye-opening results against melanoma — the deadly kind of skin cancer — and tangible gains against other malignancies.

The results have sent a jolt through a research community that had grown doubtful about harnessing the immune system to fight cancer. "The sun is finally rising," says oncologist Michael Postow of Memorial Sloan Kettering Cancer Center in New York City. "I think this is going to be a big deal for a long time."

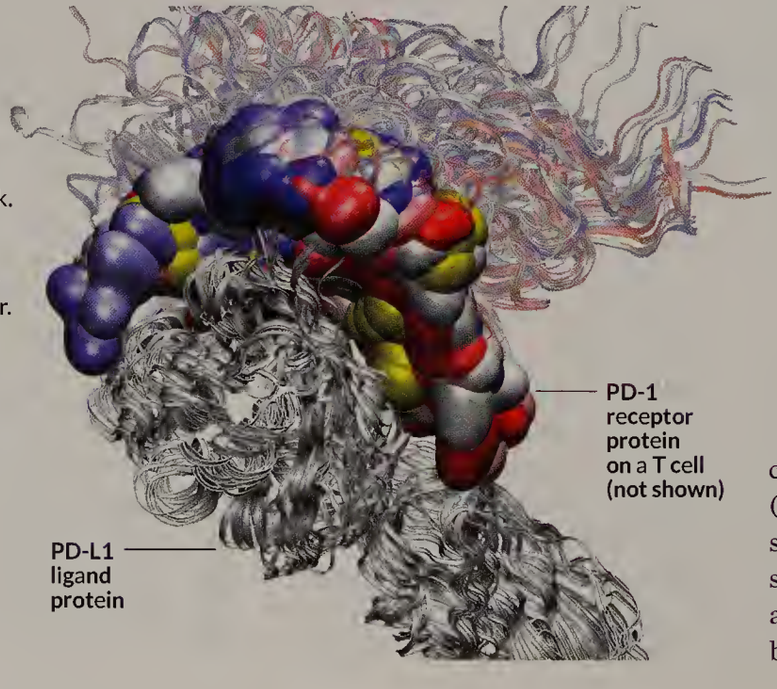
Clinical trials reported in late 2014 suggested a high upside for checkpoint drugs in patients who had run out of options against melanoma and cancers of the kidney, bladder and lung (*SN: 12/27/14, p. 8*). And new studies presented at two recent cancer meetings have fed the optimism with promising results against those cancers and others. Some of the first trials combining two checkpoint stoppers in patients have yielded impressive results. And although the dual-dose approach causes some side effects, it is unclear whether these are worse than the downsides of chemotherapy.

In one study, Postow and an international team identified 945 people with inoperable melanoma that had spread to areas beyond the skin. The patients were given either ipilimumab or nivolumab or both. These drugs each target a distinct checkpoint protein on frontline troops, aptly named killer T cells. Nearly 58 percent of those getting both drugs showed substantial tumor shrinkage in subsequent months, the standard yardstick of a good response. Almost 44 percent of those getting just nivolumab saw their tumors shrink, as did 19 percent of patients receiving only ipilimumab, Postow and colleagues reported in May at a meeting of the American Society for Clinical Oncology in Chicago and in the *New England Journal of Medicine*.

Three other studies, all published in the *New England Journal*, have had revealing results as well:

- In a subset of patients with particularly difficult-to-treat melanoma, 44 of 72 getting the two checkpoint drugs had a good response compared with just four out of 37 getting ipilimumab alone, researchers reported in April at a meeting of the American Association of Cancer Research in Philadelphia.
- In patients with relapsed or unresponsive Hodgkin's lymphoma, 11 out of 23 showed improvement after 24 weeks on nivolumab and were able to stay on the drug; a few others who initially responded relapsed and two patients went off the drug because of side effects.
- In 272 lung cancer patients with a poor prognosis, nivolumab by itself outperformed the standard chemotherapy drug docetaxel; after one year, 42 percent of patients on the checkpoint drug were still alive compared with 24 percent of patients on the chemo drug. These results, presented at the Chicago meeting, are "pretty unheard of," says study coauthor Julie Brahmer, an oncologist at Johns Hopkins University.

For decades, immunotherapy to fight cancer has been marked by fits and starts (*SN: 6/14/14, p. 22*). Part of the problem seems to lie in the checkpoints themselves. It does little good to supercharge an immune response if killer T cells can be lulled to sleep on the job.



Lock and load In this computational image, a ligand protein binds to precise spots (yellow) on a T cell's receptor protein PD-1, acting like a key in a lock. This activates PD-1 to send a signal that puts the T cell to sleep, making it oblivious to cancer. The precise modeling shown here may help researchers create drugs that disrupt the connection — awakening T cells and making cancer "visible."

K. BARAKAT AND M. AHMED/*RECEPTORS & CLINICAL INVESTIGATION* 2015

Checkpoint drugs inhibit the inhibitors of the immune system. The newer approach "releases the parking brake" on T cells that have reached a tumor only to turn quiescent, says Drew Pardoll, an immunologist and oncologist at Johns Hopkins.

Not all patients benefit from the checkpoint drugs, Pardoll says, in part because tumors have found several ways to sabotage immune reactions. But the early data suggest that 20 to 35 percent of cancer patients might benefit from overriding the checkpoints, he estimates.

The two best-understood checkpoint proteins are called PD-1 and CTLA-4. These T cell proteins are known as receptors. Other proteins called ligands fit precisely into receptors to activate them, instructing the T cell to nod off. It's no accident that this happens at a tumor's doorstep: Cancer can produce such ligands and induces immune cells to do the same.

By stopping this ligand-receptor interaction, the new drugs sabotage the checkpoint and awaken the killer T cells, which then identify cancerous cells and attack them. The veil is lifted.

Several pharmaceutical companies are working on prospective checkpoint drugs. It's becoming clear that ipilimumab, which thwarts CTLA-4, is not as potent as either of the drugs that target PD-1 — nivolumab and pembrolizumab. That may be because CTLA-4 often shows up on other T cells, not just the killer T cells on the front lines, and thus may have an indirect effect on the tumor. Other compounds being tested take aim at the ligands themselves.

Not surprisingly, scientists are testing these drugs on all kinds of malignancies. In urinary tract cancer patients, seven of 28 patients getting pembrolizumab showed a measurable improvement. In an ongoing study, the ligand-targeting drug candidate avelumab induced tumor shrinkage of 30 percent or more in at least 11 of 75 women with advanced ovarian cancer. And a small study of colorectal cancer patients finds that those with tumors harboring DNA-repair deficiencies fared better after getting a PD-1–blocking drug than did patients with normal DNA repair. This abnormality might enable doctors to identify colorectal cancer patients likely to benefit from PD-1 inhibition, Pardoll says.

Immune checkpoints serve a purpose, of course, acting as shutoff switches. This fail-safe characteristic — known as immune tolerance — is lacking in autoimmune diseases such as rheumatoid arthritis in which unbridled immune responses damage one's own tissues. PD-1 and CTLA-4 are agents of immune tolerance, says Khaled Barakat, a physicist who works on drug design at the University of Alberta in Edmonton, Canada.

> The results have sent a jolt through a research community that had grown doubtful about harnessing the immune system to fight cancer.

The risk of collateral damage makes reducing immune tolerance in people a tricky business. The combination of ipilimumab and nivolumab hit cancer hard in the large melanoma trial, but it also resulted in side effects so severe that 36 percent of patients on the two drugs had to stop taking them before getting all the prescribed doses.

"Toxicity is greater with the combination," Pardoll says. "Combo enthusiasts would say that if you know what you're doing — and can manage to mitigate the side effects — you can get patients through in a vast majority of cases."

Part of the problem could be the drugs themselves, which are monoclonal antibodies specifically aimed at these receptors or ligands. The drugs often act within weeks. But other times, responses seem delayed, Postow says, with tumor shrinkage that doesn't show up until after patients have stopped taking the drugs. The reason is unclear.

Late benefit is better than none, but it creates uncertainty in how best to prescribe the drugs and still manage the side effects. Brahmer says the antibodies themselves don't linger in the system. "We think we're creating memory in the T cells, so they remember what they are supposed to be targeting," she says. "But the side effects can linger."

20–35
percent
Estimated fraction of cancer patients who may benefit from checkpoint drugs

Barakat says a better approach might be to use faster-acting drugs that risk fewer side effects. His lab is embarking on a five-year quest to come up with compounds that hit receptors and ligands with more precision and quell the checkpoints for shorter periods. This "small-molecule" approach might also unearth compounds that can reach walled-off parts of the body, such as the brain.

Cancers don't respond uniformly to the checkpoint antibody drugs. But some tumors that show early exciting responses are heavily mutated, Brahmer says, such as melanoma (with DNA mutated by ultraviolet rays) and lung cancer (DNA mutated by cigarette smoke). Such tumors might give off a lot of antigens, molecules that draw immune attention. These antigens cause immune forces to mass, possibly providing an army that's ready to go when a checkpoint gets lifted.

Meanwhile, researchers are combining the new drugs with radiation and other cancer treatments. Radiation might harass a tumor into producing more antigens, which could boost the impact of checkpoint drugs, Brahmer says.

With each positive finding, immunotherapy gains some credence. There was a time when other scientists "thought immunotherapists were a little bit crazy," Brahmer says. "People who weren't believers are becoming believers now." ■

New geologic comparisons suggest that the Grand Canyon is less than 12 million years old.

EARTH & ENVIRONMENT

Grand Canyon's age revised, again

Triceratops and *Tyrannosaurus rex* never peered over the Grand Canyon's steep slopes, new research suggests.

Estimates of the canyon's origins vary from under 6 million (*SN: 1/25/14, p. 22*) to more than 70 million years ago (*SN: 1/12/13, p. 15*) — old enough for dino visitors. A comparison of the Colorado Plateau's rocky features now concludes that the older, western section of the canyon had to have been carved out much more recently than 12 million years ago.

The giveaway is the nearby Grand Wash Cliffs, researchers from Arizona State University report online June 10 in *Geosphere*. These cliffs formed 18 million to 12 million years ago as a fault shifted the ground. In the millions of years since then, erosion has transformed the steep cliffs into more gradual slopes. Cliffs along the western Grand Canyon are comparatively much steeper, the researchers found, suggesting that the canyon walls formed more recently than the Grand Wash Cliffs and significantly later than the big dinosaur die-off. *— Thomas Sumner*

ATOM & COSMOS

Saturn's widest ring measured

Saturn's rings reach farther than the eye can see — and astronomers now know just how far. The outermost band of dust, best seen in infrared light, is about 33 million kilometers in diameter, or at least 270 times as wide as the giant planet, researchers report in the June 11 *Nature*.

The nearly invisible belt, first detected in 2009, appears to be fed by debris chipped off the tiny moon Phoebe. Researchers couldn't measure the full extent of the dark ring then. More recent images from the infrared WISE satellite, however, let planetary scientist Douglas Hamilton of the University of Maryland in College Park and colleagues get a better look. *— Christopher Crockett*

BODY & BRAIN

Antibiotics can treat appendicitis

For people with appendicitis, surgery may not be the only option.

In a new study, antibiotics successfully treated the majority of cases of uncomplicated acute appendicitis, where the appendix is inflamed but hasn't burst or developed stones or infected pockets, researchers report in the June 16 *JAMA*.

The standard treatment for appendicitis has been to surgically remove the appendix, a cigarette-sized pouch near the start of the large intestine. In the new trial, researchers in Finland randomly assigned 530 appendicitis patients to be treated with either surgery or antibiotics.

Surgery successfully resolved 99 percent of appendicitis cases. But antibiotic treatment could be a first line of defense: Almost 73 percent of patients who got antibiotics avoided surgery in the year following treatment. *— Meghan Rosen*

ATOM & COSMOS

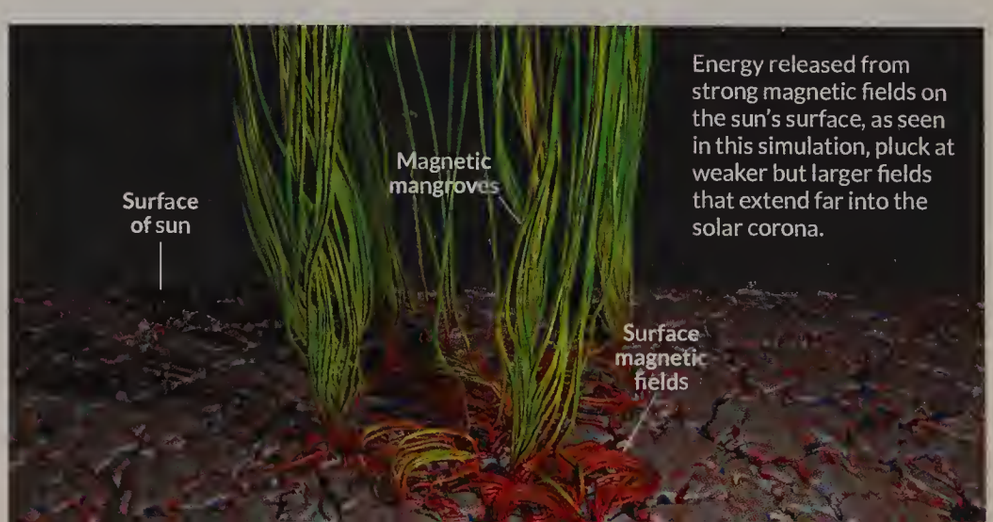
Some solar magnetic fields act like forests

Treelike magnetic fields, deeply rooted within the sun and stretching far into its atmosphere, might explain why the solar corona is millions of degrees hotter than the sun's surface. This swaying forest of magnetic mangroves can carry energy up into the corona thanks to a foaming sea of stronger magnetism close to the surface, researchers report in the June 11 *Nature*.

The roiling surface of the sun creates a tangled mess of magnetic fields, astrophysicist Tahar Amari of École Polytechnique in Palaiseau, France, and colleagues report. Their computer simulations show that these fields twist and break, dumping energy just below the corona, an enormous plasma bubble that envelops the sun. These eruptions in turn rock the weaker mangrovelike fields, which can extend 100,000 kilometers into space and carry the energy the rest of the way to the corona via waves rippling along their trunks.

The sun's surface simmers at about 5,500° Celsius; the corona, however, is a scorching few million degrees. How the corona gets so hot is a problem that has vexed astronomers for decades.

Recently observed nanoflares within the corona can reach 10 million degrees (*SN: 5/30/15, p. 7*), but researchers aren't certain how these flares are generated. Nanoflares could be caused by plasma reacting to movements of the treelike magnetic fields, Amari says, but it's too early to say for certain. *— Christopher Crockett*



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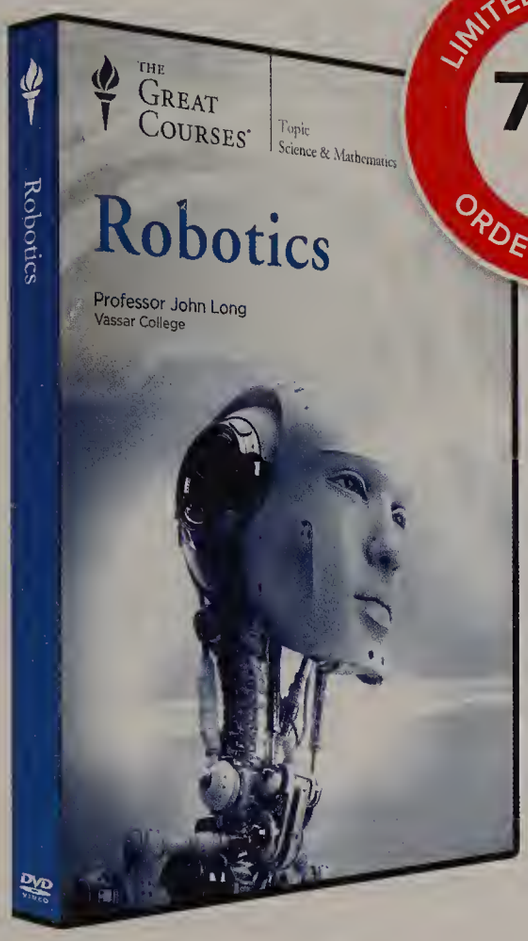

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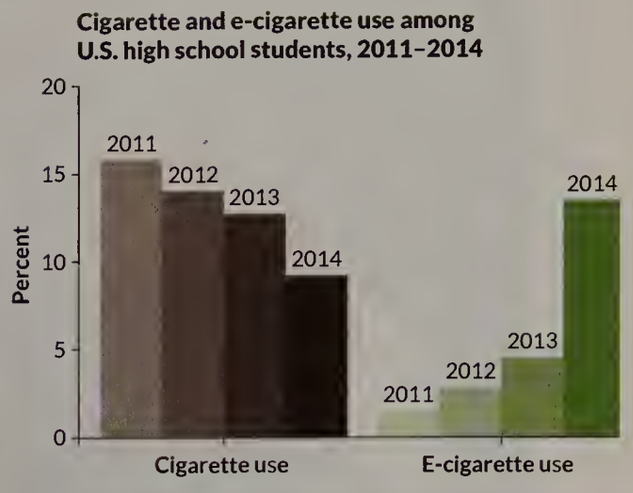
The Dangers of Vaping



Teens are falling for flavored e-cigs, but the vapors they inhale may be toxic

By Janet Raloff

They've appeared on television and in magazines — Katy Perry, Johnny Depp and other celebrities vaping electronic cigarettes. The high-tech gadgets, marketed as a healthier alternative to traditional cigarettes, seem to be available everywhere, from Internet suppliers and specialty vaping shops to 24-hour convenience marts.

E-cigarettes have become the fashionable new electronic toy. With vape flavorings like bubble gum, Dr Pepper and cotton candy, teens have been taking the bait. In 2014, e-cigarettes surpassed cigarettes as the most commonly used tobacco product by middle school and high school students, according to an annual U.S. survey.

Teens' fascination with this nicotine-dispensing smoking alternative worries physicians and toxicologists. Data from a growing number of studies indicate that electronic cigarettes are far from harmless. They also pose their own addiction risk.

Chemicals in e-cigarettes can damage lung tissue and reduce the lungs' ability to keep germs and other harmful substances from entering the body, studies have found (*SN: 12/27/14, p. 20*). The flavored e-cig liquids can do their own damage. And the lungs — not to mention the young brain (see "Nico-teen brain," Page 20) — may be particularly vulnerable to nicotine's effects.

"What I can say definitively is that nicotine is harmful to the developing teenage brain," says Mitch Zeller, director of the Center for Tobacco Products at the U.S. Food and Drug Administration in Silver Spring, Md. "No teenager, no young person, should be using any tobacco or nicotine-containing products." E-cigarettes, he says, are among the products that should be kept firmly out of the hands — and mouths — of adolescents.

Soaring popularity

In the last year, e-cigarette use by U.S. teenagers tripled — from 4.5 to 13.4 percent among high school students and from 1.1 to 3.9 percent among middle schoolers, according to data from the annual National Youth Tobacco Surveys (sponsored by the FDA and the Centers for Disease Control and Prevention). Other surveys, some national, some state-level, offer even more troubling figures.

A 2014 survey of U.S. teens, for example, found that almost 9 percent of eighth-graders had vaped in the 30 days before they were questioned. Among 10th-graders, 16.2 percent had vaped in the previous 30 days versus 7.2 percent who had smoked. Teens don't see e-cigs as dangerous, suggest the data from a University of Michigan study, released last December. Only 14.2 percent of 12th-graders surveyed viewed vaping as harmful.

In some parts of the country, e-cigarette use by young people is especially high. In Hawaii, 29 percent of more than 1,900 ninth- and 10th-grade students in five schools had at some time

In 2014, e-cigarettes became the most commonly used tobacco product among teens. The devices surpassed cigarettes, which have been on the decline, according to a national survey by the CDC and FDA.
SOURCE: 2011–2014 NYTS

JOHN VAN HASSELT/CORBIS

used e-cigarettes, according to a survey published in *Pediatrics* in January.

And teen vaping is hardly restricted to Americans. A new survey of nearly 2,700 German seventh-graders finds that almost 5 percent have vaped. A May report in the *Journal of Adolescent Health* describes a near tripling in vaping among teens in New Zealand between 2012 and 2014. By 2014, one in five 14- to 15-year-olds there had given it a try. Reported use by high school teens in Poland is even higher: 23.5 percent.

Such trends, Zeller says, "should raise alarm bells for parents and educators."

Smokeless nicotine

Unlike true cigarettes, electronic cigarettes don't burn tobacco. They don't burn anything. Instead, the battery-operated devices turn a flavored liquid into a vapor. Users inhale, or vape, the mist. The liquid usually contains nicotine, a natural stimulant in tobacco that is highly addictive. Also in the liquid are solvents, flavorings and who knows what else.

E-cigarettes first appeared in the U.S. market in 2007, designed to help tobacco addicts wean themselves from smoking. Recent research, however, indicates that vaping does not boost quit rates (*SN Online: 3/24/14*).

Irina Petrache of the Indiana University School of Medicine in Indianapolis studies the impact of nicotine in e-cigs. She and her colleagues recently exposed lung tissue in the lab to nicotine alone, to cigarette smoke or to e-cigarette vapors. Compared with tissues treated with a nicotine-free soluble extract, all three types of exposures caused lung cells to become more permeable. The cells were no longer an effective barrier to outside substances.

In follow-up tests, the researchers exposed lab animals to nicotine and e-cig liquids. These exposures caused increased oxidative stress and resulted in a buildup of inflammatory cells in the lungs of the mice. "We were surprised at how quickly we saw this inflammation," she says. In fact, the affected lung surface cells "became activated" by the exposures, Petrache explains, "which means they became an active participant in the inflammation."

Her team's findings show that nicotine alone — independent of anything else in cigarette smoke or e-cig vapors — can harm lung tissue. While neither nicotine nor the vapors were quite as potent as the cigarette smoke, all three were triggers. "It took a somewhat larger amount of e-cigarette vapor or nicotine to cause the damage," she explains. Her group reported its findings online May 15 in the *American Journal of Physiology — Lung Cellular and Molecular Physiology*.

In an "unexpected and disturbing" result, Petrache's team found that even an e-cigarette liquid with no nicotine can disrupt the barrier function of lung cells. Her group suspects this problem may have to do with soluble components, such as nicotine or the compound acrolein, in the flavored liquids that are inhaled through e-cigarettes. Despite a public perception to the contrary, vaping "does not seem to be harmless," Petrache concludes.

Irfan Rahman of the University of Rochester Medical Center in New York has a good idea of what was behind the inflammation witnessed by the Indiana team: free radicals spawned as the flavored e-cigarette liquids vaporized. Indeed, he was surprised to learn how potent a source of free radicals e-cigarettes can be. Free radicals, with one unpaired electron, can damage cells and derail the immune system (*SN: 4/18/15, p. 9*).

Rahman, a biochemist, and his team drew the vapors from e-cigarettes into sophisticated test equipment that his lab uses to measure free radicals. Some vaped puffs created from flavored e-liquids — with or without nicotine — produced high concentrations of free radicals. In fact, the nicotine-free vape liquid produced a substantially higher concentration of free radicals, Rahman's team reported in February in *PLOS ONE*.

In other experiments, Rahman's team quantified the free radicals from vaping and smoking. Puffs from both contained free radicals aplenty; the quantity in each vaped puff exceeded those in a puff of cigarette smoke.

To further explore e-cigarette use, Rahman and students from his lab began frequenting vape shops and talking to the teens and young adults who had come to buy supplies. The vapers bragged about being able to use e-cigarettes indoors where smoking was banned, that e-cigs could cost far less than cigarettes and that their colors, potency and flavors could be personalized to deliver a truly "individual" experience.

Some vapers described how they customize the vaping experience by eliminating the cartridge of e-liquid, also known as "e-juice," and using an eye dropper to drip a flavored solution directly onto the e-cigarette's heating element. Then they breathe in the vapors that rise off the coils. This technique, called "dripping," delivers a more potent hit of nicotine, users told Rahman. It also allows them to switch between flavors more easily

— an advantage at parties and in groups where people share an e-cigarette.

Rahman and colleagues investigated how dripping (see image, left) might affect the vapor profile. They found that it upped production of free radicals dramatically.

Many teens and young adults told Rahman and colleagues that their throats became dry and scratchy with vaping. Some said that vaping made them cough or choke and that their mouths bled. Rahman says he decided, "We've got to start looking into these things and see what's going on."

So his team exposed human lung cells and mice to e-cigarette vapors. The vapors triggered intense inflammation in both. Preliminary data from Rahman's team indicate that vaping can cause DNA damage in test tube–grown cells. More worrisome: In one of his team's lung cancer cell lines, e-cigarette vapors triggered precancerous cells to act more like malignant cells. "They go from bad to worse," Rahman says. Surprisingly, he says, cigarette smoke did not show this effect.

Studies by his group and others, Rahman says, suggest that vaping is not safer than smoking: "It's equally bad."

Weakened defenses

Last year in San Diego at a meeting of the American Thoracic Society, Laura Crotty Alexander reported that vaping can make it harder for the body to kill germs (*SN: 6/28/14, p. 9*). Crotty Alexander, a pulmonologist, works at the Veterans Affairs San Diego Healthcare System.

In the lab, she exposed *Staphylococcus aureus* bacteria to e-cigarette vapors, hoping to create conditions that would somewhat mimic what the germs might encounter in the lungs of an e-cig user. The bacteria exposed to high levels of nicotine covered themselves with a thicker biofilm coating than normal, which bolstered their protection.

Crotty Alexander then allowed mice to breathe in air containing these vaping-exposed bacteria. By the next day, the mice had three times as many bacteria in their lungs as did mice exposed to normal Staph bacteria. Fighting off the germs exposed to e-cigarette vapors proved hard for the mice.

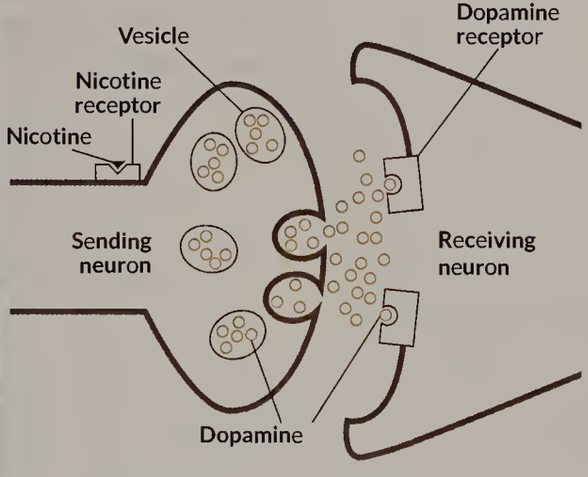
Inflamed lungs with an impaired barrier might help explain why more germs made it into the mice's lungs. Thomas Sussan of the Johns Hopkins University Bloomberg School of Public Health and colleagues found similar connections between vaping and immune dysfunction.

Sussan's team tallied the free radicals from vaping, measuring 700 billion or so free radicals per puff (*SN Online: 2/4/15*). Then, as Rahman's group had done, Sussan and collaborators pumped e-cig vapors into a shoebox-sized chamber. They placed mice in the box for 90 minutes, twice daily, over a two-week period to inhale those vapors.

Nico-teen brain

The teenage brain is no place for nicotine. The prefrontal cortex, the area of the brain responsible for emotions and impulse control, doesn't finish developing until age 25 or so. It's an area especially vulnerable to nicotine addiction.

Exposing the developing adolescent brain to nicotine "could lead to a high risk of lifelong addiction," says Garry Sigman, who heads adolescent medicine at the Loyola University Chicago Stritch School of Medicine in Maywood, Ill.



Brain interrupted Nicotine (black triangle) tricks the nerve cell sending a message into releasing more dopamine (yellow dots) into the synapse than it would normally, giving users a feel-good high, but potentially creating addiction and other problems down the road.

Nicotine can reach the brain within seven seconds of inhaling. The drug then acts like a key, unlocking special receptor molecules that cause nerve cells in the prefrontal cortex and other parts of the brain to release neurotransmitters, such as dopamine and serotonin, into the synapse, where nerve cells communicate. Users get a feel-good high. After repeated exposure to nicotine, however, fundamental changes in the brain can interfere with the body's ability to release natural pleasure-giving chemicals on its own. Teen brains will also create more receptors to handle the flood of nicotine. As the number of receptors increases, teens need more nicotine to get the same high. That makes nicotine users seek hit after hit. In teens, behavioral consequences, including impaired attention and bouts of depression and anxiety, can emerge, research suggests.

While some of the negative effects of nicotine on the young brain can fade with time if exposure ends, others may persist. Neuroscientists at VU University Amsterdam found that nicotine treatment in adolescent rats increased impulsive behavior and impaired attention during adulthood. — *Teresa Shipley Feldhausen*

FROM TOP: CINDY YAMANAKA/CORBIS; NATIONAL INSTITUTE ON DRUG ABUSE, ADAPTED BY J. HIRSHFELD

Afterward, the animals' lungs showed substantial signs of oxidative stress and inflammation. Compared with unexposed mice, the vaping mice had "a nearly 60 percent increase in inflammatory cells," Sussan says. The influx of immune system macrophages in the airways was similar to what his group had seen in mice exposed to cigarette smoke.

To test whether this lung damage affected immunity, Sussan's team exposed some of the "vaped" animals to either flu virus or *Streptococcus pneumonia* bacteria. Normally, macrophages would gobble up and kill the pathogens. The vaped animals produced plenty of macrophages, but the scavenger cells didn't do their job. The result: "defective bacterial clearance," the researchers reported in February in *PLOS ONE*.

Similarly, mice that had breathed in e-cig vapors proved less able than nonvaping mice to fight off the flu virus. Some of the mice exposed to the e-cigarette vapors died. All nonvaping mice survived.

The emerging animal data show that "clearly, these e-cigarettes aren't safe," concludes Sussan, a toxicologist. In fact, he says, any vapers "who think they are not doing any harm are fooling themselves."

The Wild West

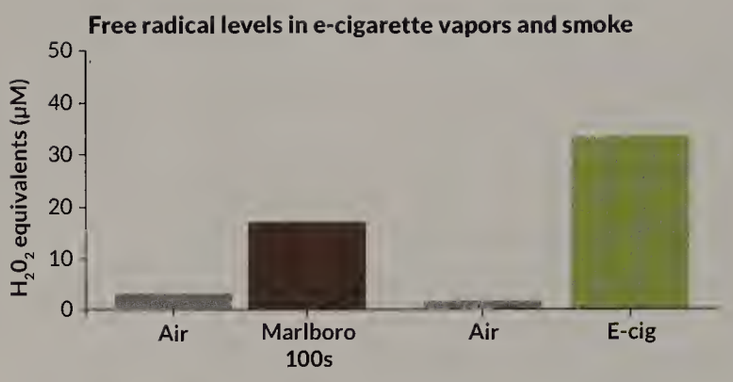
A challenge to probing any risks associated with e-cigs is the lightning pace with which the vaping environment has been evolving. In January 2014, at least 466 brands of e-cigarettes were for sale, according to a recent Internet survey by researchers at the University of California, San Diego. Each brand had its own website. That same survey turned up 7,764 uniquely named flavored e-liquids, with hundreds of new flavors appearing each month.

Sussan calls the e-cig market "the Wild West." Tests on one device or flavored liquid may not extrapolate to others being sold. Makers of e-liquids don't have to list their ingredients and nicotine amounts. And when listed, they aren't reliable, several studies have found. Few flavorings in the e-juices have been evaluated for risks to the lungs.

A few research teams are trying to get a handle on what's out there. Researchers at Portland State University in Oregon recently purchased and analyzed 30 e-juices. "The levels of flavorings that we found in some of the fluids were high — sometimes as much as 4 percent of the material," says chemist James Pankow. That was unexpected, he says. His team published its findings online April 15 in *Tobacco Control*.

Industrial safety guidelines recommend workplace inhalation limits for some of the chemicals his team found in vaping liquids. Examples include the aldehydes vanillin and benzaldehyde. Based on the quantities of some of these chemicals found in the e-juices, people who chronically vape could inhale amounts greater than those recommended for employees, Pankow notes.

In addition, he says, breathing something is very different from eating it. The gastrointestinal tract is better able than the lungs to tolerate incoming materials. Even the Flavor Extracts Manufacturers Association, he says, argues that it would be "false and misleading" to claim that food-grade flavorings are inherently safe to vape.



Oxidative stress Tobacco-flavored e-cig vapor (10-minute exposure) contained more free radicals than smoke from conventional cigarettes (five-minute exposure) or air. SOURCE: CHAD LERNER *ET AL/ENV. POLL.* 2015

Certain other chemicals added to cigarettes to make them easier to smoke are found in e-cigs as well, a team at the Harvard School of Public Health reports. The researchers sifted through a mountain of tobacco company documents released to the public in the 1990s as part of a legal settlement.

"What we found," says Hillel Alpert, "is that they added ingredients — particularly pyrazines — that appear to have contributed to the 'smooth' flavor, reducing the harshness of certain cigarettes." Pyrazines are also being added to e-cigarette fluids, his team wrote online June 10 in *Tobacco Control*. Such chemicals may mask the body's natural aversion to irritating aspects of vapors, making them easier to inhale. This might indirectly foster addiction, Alpert says. Simply put: Pyrazines can make it easier for teens to comfortably take in nicotine.

Arguing for regulations

Vaping products remain largely unregulated in the United States and elsewhere. The FDA announced in April 2014 that it plans to extend its regulation of tobacco products to include e-cigarettes. The agency has not yet acted on that proposal.

As of December 2014, in 10 states and the District of Columbia, children can legally buy e-cigs. And to buy them on the Internet, minors just have to claim they are adults.

On April 28, a broad consortium of 31 organizations — from the American Lung Association and American Academy of Pediatrics to the United Methodist Church — sent an open letter to President Obama asking him to light a fire under the FDA about regulation of e-cigarettes and other unregulated tobacco products. Without action, the groups charged, "there are no restrictions in place to protect public health against the risks these products pose, particularly to the health of our children." ■

Explore more

- Shu-Hong Zhu *et al.* "Four hundred and sixty brands of e-cigarettes and counting: Implications for product regulation." *Tobacco Control*. July 2014.

Dots

Tiny quantum particles illuminate the body's innermost workings

By Alexandra Witze

Warren Chan helped invent a research field and then watched it nearly die.

The chemist and biomedical engineer at the University of Toronto specializes in quantum dots, tiny semiconductor particles that glow in a rainbow of colors when zapped with a laser. Fifteen years ago, quantum dots were all the rage. Scientists dreamed of the wild things they could do with them (*SN: 6/3/06, p. 344*).

Perhaps quantum dots could glow in a futuristic, superbright television screen. Or maybe doctors could hook them to a cancer-fighting drug to watch the medicine spread through the body and attack the tumor. In 1998, Chan and Shuming Nie, then at Indiana University in Bloomington, were among the first to describe how quantum dots could light up the inner workings of living cells.

In the years since, the television screens became reality: Quantum dot displays with vibrant colors are hot items at consumer electronics shows. But researchers struggled to get quantum dots to perform safely and predictably in living cells. Chan's dreams remained wild.

More recently, though, the barriers to quantum dot progress seem to be crumbling. Within the last few months, Chan has finally succeeded in building one of the devices from his dreams. It's a smartphone attached to a lab-on-a-chip, which uses quantum dots to detect viruses such as HIV or hepatitis lurking in a person's blood. It is almost as accurate as a traditional lab test, while a lot cheaper and portable. Doctors could use it outside of hospitals.

Other researchers are shrinking quantum dots, making them tiny enough to track the flow of

Tiny semiconductor particles called quantum dots light up mouse intestines in this microscope image. Red and green represent proteins illuminated by fluorescing quantum dots. Cell nuclei are stained blue with a traditional dye not involving quantum dots.

PROVIDED BY THERMO FISHER SCIENTIFIC. IMAGE BY THOMAS DEERINCK AND MARK ELLISMAN/NATIONAL CENTER FOR MICROSCOPY AND IMAGING RESEARCH

single particles among brain cells and other microscopic systems. Some scientists are taking an apparent drawback of quantum dots — that their brightness flickers in and out like a firefly's — and turning it into an advantage by creating incredibly detailed images of cell innards.

Quantum dots still may not launch the revolution that some biologists had hoped for, but the field is clawing its way back to relevance. The ultimate goal now is to provide a new way to illuminate how cells work, turning a series of small laboratory advances into something that helps doctors and patients better track and fight disease.

"I still believe quantum dots are very cool," Chan says.

Under ultraviolet light, yellow and green quantum dots are easier to see through mouse skin than red quantum dots.

Minisemiconductors

Quantum dots combine everyday chemistry with extraordinary physics. They are made of standard semiconductor materials such as cadmium selenide, but their size gives them astonishing properties. The core of a typical quantum dot measures from a few to more than 20 nanometers, or billionths of a meter, across. It is so small that its electrons behave much as they would in an individual atom, observing quantum mechanical rules (hence the "quantum" in its name). Electrons jump between individual energy states, in the process emitting photons of a particular wavelength of light.

Because they can be produced in a variety of small sizes, quantum dots can be "tuned" to emit light in whatever wavelength a scientist wants. A larger quantum dot emits red light, while a small one glows blue. By tweaking the size of the dots, researchers can coax them to sparkle in a rainbow of colors.

Quantum dots are also much brighter and last longer than fluorescent dyes, the traditional tool for staining living cells. That makes the dots good candidates for studying how drugs flow within the body and how proteins and other biological molecules go about doing their jobs over hours or even weeks.

When quantum dots first entered the scene, some experts thought they might eclipse fluorescent dyes and become the material of choice for studying living cells. There's just one problem, though, and it's major: Cadmium, the heart of most commercially produced quantum dots because it glows so brightly and reliably, is toxic in high doses. In the early 2000s, a series of papers showed how quantum dots made with cadmium selenide could actually kill cells in a petri dish. Those studies scared many biologists away from working with the dots, says Russ Algar, a biochemist at the University of British Columbia in Vancouver.

Algar thinks that toxicity fears have unfairly stalled the field. Studies in live animals suggest that cadmium can be used at levels that aren't toxic to the body, he notes. And studies in cell cultures generally don't last long enough for researchers to have to worry about whether cadmium is killing the cells. In addition, quantum dots are not all alike — many of them are packaged inside outer layers that safely contain the cadmium, or at least mitigate how much of it leaks into its environment. "This idea that quantum dots should be written off because they contain a heavy metal isn't a fair assessment," Algar says. "That's potentially closing the door on some opportunities."

Size matters

While some researchers try to work out, or work around, the toxicity issues, others have found a way to turn quantum dots' unpredictable blinking into an asset. The flickering may have something to do with cycles of electrical charging and discharging in the dots' cores. The blinking makes it hard to continuously track every move of a particle within a cell.

At the University of Illinois at Urbana-Champaign, biophysicist Paul Selvin has embraced the blink. He uses a technique known as super-resolution fluorescence microscopy, whose inventors shared the 2014 Nobel Prize in chemistry (*SN: 11/1/14, p. 15*). It relies on flickering particles to take sharper images of very small molecules than would otherwise be possible.

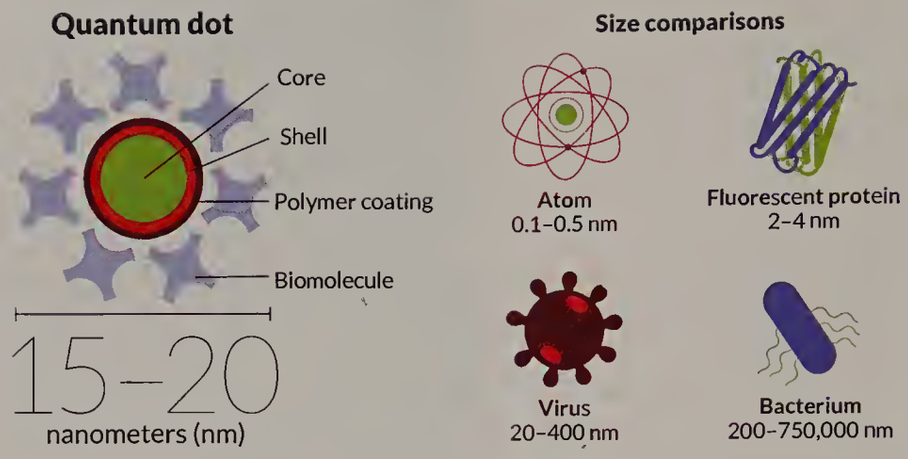
Normally, the wavelength of light in a microscope limits the size of the items that researchers can see; anything tinier than about half of the light's wavelength (about 200 nanometers for visible light) simply can't be spotted in an ordinary optical microscope. But scientists can get around this limit by taking a handful of molecules and making them glow, a few at a time, in the area they want to image. By allowing a few particles to light

Bigger is redder Changing the size of a quantum dot core changes the color it emits. The larger the dot diameter, the redder the light.

FROM TOP: EDWARD SYKES AND W. CHAN/UNIV. OF TORONTO; ANTIPOFF/WIKIMEDIA COMMONS (CC BY-SA 3.0)

Second chance

Quantum dots, smaller than most viruses and bacteria, are typically made of a semiconductor material such as cadmium selenide, enveloped by a shell and an outer coating of a polymer to help it slip through living cells. A biomolecule on the outside helps direct the dot to a specific tissue in the body. Concerns about cadmium's toxicity have limited the dots' use in biology, but that may be changing.



up, and then turning them off and letting another few particles glow, the researchers can superimpose the images and come up with a picture that is higher resolution than before.

Although super-resolution microscopy usually uses traditional fluorescent dyes, quantum dots can do the job well, Selvin says. In 2013 in *Nano Letters*, his team reported taking super-resolution pictures of epidermal growth factor receptors, molecules involved in the growth of breast cancer cells, using quantum dots. Understanding how the receptors work could help scientists learn more about how the cancer spreads.

More recently, Selvin has used the technique to track the step-by-step action of proteins that act as molecular motors to move other proteins around within a cell. "These quantum dots are really pretty amazing," he says. "They are so good that you can see in all three dimensions."

Even though quantum dots measure just nanometers across, that can still be a bit too big for tight spaces like the junctions between cells. Most commercially available quantum dots are 20 nanometers or more across. Their cores are much smaller, but a thick shell surrounds the core to safely insulate the cadmium metal from the environment. An additional polymer coating allows the dot to flow freely within a cell. These commercial quantum dots can be used for biological imaging, but they aren't always ideal for squeezing into all parts of a cell.

Many research teams have been working to fashion thinner shells that still sequester the cadmium. Selvin, for instance, takes a core of cadmium selenide and then adds a sulfur atom and a chain of 11 carbon atoms. He coats the whole thing in a polymer to make it move easily in water. If the layers are added at high temperatures in the absence of oxygen, the coating molecules form a dense, tight layer around the core. The result: quantum dots that are only about 9 nanometers across. Selvin and collaborators made the dots glow at four different wavelengths. The glow lasted for more than a month, the team reported last year in *Angewandte Chemie*.

The small quantum dots are only about one-third as bright as a larger commercial dot, but that's still bright enough for Selvin. In a lab dish he hooks them up to AMPA receptors — molecules in living nerve cells, or neurons — and tracks how they travel.

The dots are small enough to squeeze into the synaptic cleft, a space about 20 to 40 nanometers across where one neuron passes a signal to another. "The smaller dots can actually get inside," Selvin says. So "we're getting a very different view of how these synapses work."

For instance, the small quantum dots showed that most of the action happens within the synapse itself, not at locations just outside the synapse. Watching the whole thing with big quantum dots had misled scientists into thinking that the area outside the synapse, which was the only place the big dots could go, was perhaps more important than it is, Selvin says.

Magnetic moves

There are times when quantum dots don't have to be small to be helpful. MIT chemist Moungi Bawendi has used the dots to help build "supernanoparticles" with a very attractive property: They are magnetic and can be guided to a specific place in a cell by applying a magnetic field. Ordinary quantum dots and fluorescent dyes can't do that.

Bawendi's team coaxed cadmium-based quantum dots to cluster around magnetic iron oxide nanoparticles, like a ring of wagons encircling a cattle herd. Together they form one larger cluster about 100 nanometers across.

Because the supernanoparticle is magnetic, researchers can steer it in a particular direction by flipping on a magnetic field. Then they can watch the brightly glowing collection as it travels within a cell.

Supernanoparticles may become a sort of Swiss army knife for biological imaging — a single package containing many handy tools, Bawendi and his colleagues reported last year in *Nature Communications*. One day scientists might even use them to steer drugs to a particular location within the body, he says.

Another disease-fighting quantum dot tool is being developed at Imperial College London, inspired by a baby's rattle. Biochemist Molly Stevens and her colleagues have built a quantum dot–filled "quantum rattle" that is no toy; it seeks out and destroys cancerous tissue by heating it.

Instead of using cadmium selenide, Stevens makes her

QUANTUM DOT: THERMO FISHER SCIENTIFIC, ADAPTED BY M. TELFER; SIZE COMPARISONS: MYSTOCKICONS/ISTOCKPHOTO, ADAPTED BY M. TELFER

quantum dots out of gold. Tiny gold particles, less than 2 nanometers across, can absorb near-infrared light and transform it into heat. These nano-sized golden warriors penetrate diseased tissue and deliver a heated punch right where it counts.

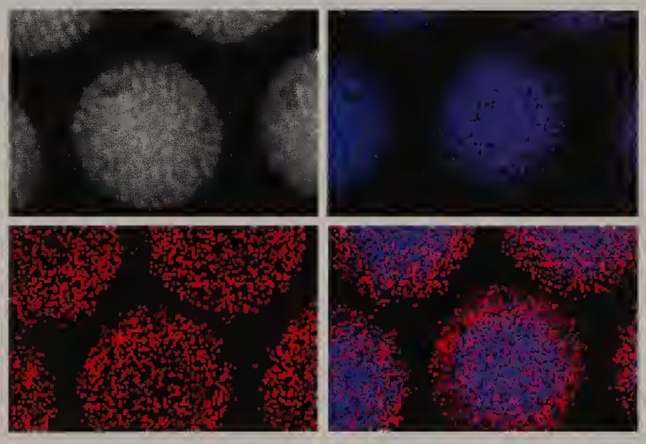
Stevens and her colleagues build the rattle using a hollow shell of silica, about 150 nanometers across. They place gold quantum dots inside along with larger particles of gold. When zapped with a laser, the quantum dots glow and give off heat.

The researchers injected the quantum rattle into tumors in mice, then blasted the tumors with a laser. Tumors containing the quantum rattle began to show signs of cells dying, unlike tumors that had been injected with hollow nanoparticles that did not contain quantum dots rattling around inside.

Quantum rattles might also help deliver cancer-fighting drugs directly to tumors, Stevens' team reported in February in the *Proceedings of the National Academy of Sciences*. In lab tests, rattles loaded with doxorubicin plus quantum dots released the drug into the surroundings a third as rapidly as silica shells containing doxorubicin but no quantum dots. A slow, extended-release delivery method could make it easier for cancer patients to tolerate their drugs.

Not all of these quantum dot discoveries will make it into your doctor's office. The supernanoparticles may be too big to flow smoothly through many types of living cells. And the quantum rattle may not work better than other approaches for ferrying drugs directly into cells. But one quantum dot application is now almost ready for prime time — and it comes from Chan in Toronto.

In March, in the journal *ACS Nano*, Chan's team reported on a quantum dot bar code device that can diagnose three different viral infections. A person places a drop of DNA from blood onto a tiny chip, and a smartphone snaps a picture and can read out whether a virus is present.



Quantum dots (red) surround iron-based particles (blue) to make supernanoparticles that can be moved in the body using magnets.

The chip is coated with microscopic beads containing quantum dots. Each bead is coated with a material designed to recognize a particular strand of DNA — for instance, a sequence that is specific to a hepatitis virus. If there is virus in a blood sample, the DNA will connect to the beads designed to detect hepatitis. If there is HIV in the sample, the DNA will connect instead to the HIV beads. "It really took about 10 years to get the chemistry to work," Chan says.

Next, a cheap laser just outside the smartphone illuminates the sample, switching on a quantum dot that begins to light up. The beads glow different colors depending on what virus is detected. The smartphone's camera shoots a picture, and an app deciphers what viruses are present based on which dots light up. Green might mean hepatitis B while red means HIV,

In this portable device to diagnose viral infections, a smartphone screen lights up with colored quantum dots based on what it views in an attached lab-on-a-chip (right).

for instance. For now, the team has focused on HIV and hepatitis B and C, but the work could be extended to other viruses as well.

Doctors can already do this type of test in a hospital, using fluorescent dyes, but making it portable and part of a smartphone opens new options. "We want to develop a device that's cheap and cost-effective so we could do the detection anywhere," Chan says. His team is using 3-D printers to fashion plastic cases to hold the beaded chip, smartphone and lasers together; the whole setup costs well under $100.

Quantum dots are bright enough for a smartphone camera to pick up their glow, and with the bar coding, multiple tests can be run at the same time. The device can detect virus-positive samples about 80 to 90 percent as accurately as a traditional laboratory test, Chan says. He is working on improving that detection rate and thinks he can start selling the quantum dot bar coder soon.

Such smartphone-based tests may be the future of quantum dots, says Algar. "If we can leverage their really excellent fluorescence properties, then we can get away with instrumentation or devices that are less complex than in the lab," he says. "Press a button on your smartphone, and if you can do some sort of useful measurements or diagnostic test that would be a great thing."

All thanks to tiny glowing specks that may be finally coming into their own. ■

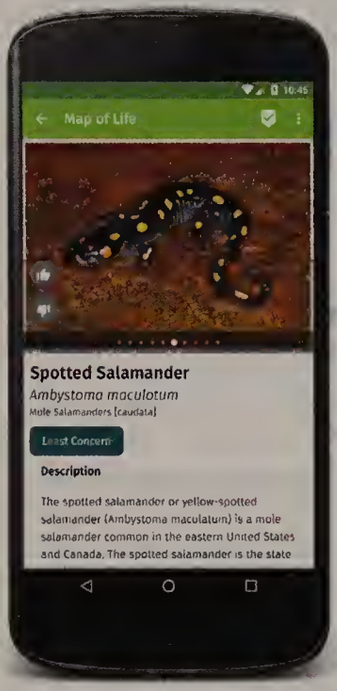
Explore more

- Brad A. Kairdolf *et al.* "Semiconductor quantum dots for bioimaging and biodiagnostic applications." *Annual Review of Analytical Chemistry.* June 2013.
- Melissa Massey *et al.* "Mind your P's and Q's: The coming of age of semiconducting polymer dots and semiconductor quantum dots in biological applications." *Current Opinion in Biotechnology.* August 2015.

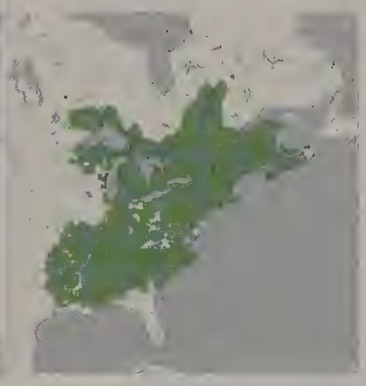
SCREENTIME

Biodiversity information at your fingertips

Part interactive field guide, part map, a new app compiles millions of records on species ranges worldwide. By pinpointing your location, the Map of Life app lets you explore plants and critters you might see nearby. Or tap around the globe to see what might be blooming in Singapore, for example. Click on a species name to reveal its range map (one shown below), as well as crowdsourced pictures.

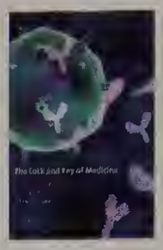


A team led by Walter Jetz of Yale University and Robert Guralnick of the Florida Museum of Natural History spent two years creating the Map of Life app, which is free for iPhones and Android. "The story of biodiversity is a visual one," Guralnick says. Citizen scientists can help tell that story by reporting species sightings.

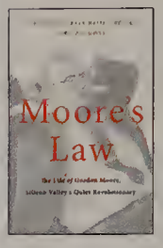


The Map of Life team plans to add a way to access records even without cellphone service. That could come in handy if you're trying to figure out if that backcountry berry is edible.
— Teresa Shipley Feldhausen

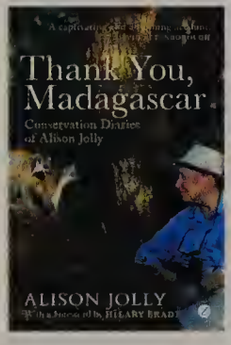
BOOKSHELF



The Lock and Key of Medicine
Lara V. Marks
Over the last 40 years, monoclonal antibodies have changed the face of disease research and health care. A historian of medicine charts their development and use.
Yale Univ., $40



Moore's Law
Arnold Thackray, David C. Brock and Rachel Jones
Two historians and a journalist document the life of Intel cofounder Gordon Moore, who had the insight that silicon would make electronics increasingly cheap and powerful. *Basic Books, $35*



Thank You, Madagascar
Alison Jolly
ZED BOOKS, $29.95

BOOKSHELF

A chronicle of conservation

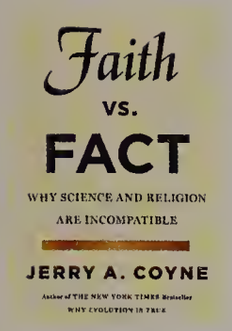
When Alison Jolly died last year, the world lost one of its leading authorities on lemurs. Jolly began studying the primates on her first trip to Madagascar in 1962 and spent much of her career documenting lemurs' social lives. But her academic work was hardly her only legacy. Like many other researchers who study endangered species, Jolly increasingly devoted her time to protecting her study subjects. These efforts are the topic of her last book, *Thank You, Madagascar*, which offers a firsthand look at conservation's difficult, time-consuming, frustrating and political aspects.

Jolly tells this story through excerpts from her diaries paired with modern reflections. The entries are grouped by theme, not chronology. Jumping around in time makes the book a bit difficult to follow at first. But it eventually settles into a rhythm, and readers will appreciate Jolly's keen observation skills, sense of humor, humility and love of Madagascar.

The country is home to hundreds of animal species and thousands of plant species found nowhere else in the world. The crux of the book focuses on a pivotal time in Madagascar's history. In 1985, the government recognized that it needed to step up protection of wildlife, which had taken a beating from pervasive slash-and-burn agriculture. Working with other scientists and government officials, Jolly helped outline, implement and monitor a comprehensive conservation program. This work included wooing bigwigs from financial institutions like the World Bank to secure funding. (One successful tactic: inviting potential partners to witness the whalelike songs of the indri, a type of lemur.) By 1991, Madagascar's National Environmental Action Plan was born.

Most striking about Jolly's account is her frank appraisal of the shortcomings of the plan she helped create. Although Madagascar has set aside tens of thousands of square kilometers for national parks and reserves, illegal logging is rampant (*SN Online: 1/16/15*). One problem, Jolly explains, is that local people did not help craft the conservation program. Having foreigners dictate where people could live and farm — sometimes forcing them to abandon their ancestors' homelands — was essentially a form of colonialism, one villager complained.

Another problem is Madagascar's widespread poverty. Conservation efforts won't succeed if plans don't include investment in sustainable development. That's where Jolly sees hope, with help from an unlikely ally. In recent years, mining companies have become interested in Madagascar's mineral wealth. If companies are compelled to mine responsibly, the human and animal residents of Madagascar may both benefit. *— Erin Wayman*



Faith vs. Fact
Jerry A. Coyne
VIKING, $28.95

BOOKSHELF

A biologist takes aim at religion

It's increasingly popular to view science and religion as complementary ways of knowing about ourselves and the universe. But that idea doesn't have a prayer of being true, argues evolutionary biologist Jerry A. Coyne in *Faith vs. Fact.*

Coyne, a veteran of battles with creationists, says science generates evidence-based knowledge while religious faith consists of unverifiable, supernatural convictions. His book joins those of Richard Dawkins and other "new atheists," who regard religious faith as delusional and religious believers as dangerously intolerant toward inconvenient scientific findings.

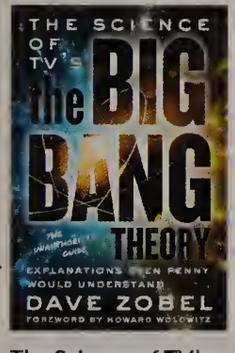
Coyne dismisses scientists who are believers by saying that people are good at explaining away inconsistencies in their own conflicting attitudes. He describes research that has shot down religious convictions such as the belief that all people are descended from one man and one woman. Some believers assert that God guided the evolutionary process to produce humans. Coyne responds that rerunning the history of the universe would not result in Earth as we know it and rerunning evolution — with its random genetic high jinks — would not inevitably lead to humans. So neither God nor anything else produces predetermined outcomes via evolution.

Religious criticisms of science get tackled in their own chapter. Scientists may at times be wrong, deceitful, arrogant and even evil, Coyne acknowledges. But such problems bedevil all people, not just those with Ph.D.s. Built-in methods of self-correction ensure that scientists eventually weed out hoaxes and hooey. In contrast, religious beliefs can be neither proven nor disproven, Coyne asserts.

He ends by arguing for a worldwide turn to secular, European-style social democracies. In these nonreligious societies forged from a wide range of cultures and political systems, Coyne predicts, opposition would recede against evolutionary theory, scientific reports of human-caused global warming, childhood vaccinations and assisted dying. People would be happier without God, he says. But his scenario rides more on faith than fact.

Coyne makes debatable points about both science and religion. While science contains powerful accepted knowledge, he underplays the importance of discoveries that increase uncertainty about what's known. Coyne portrays religion as a by-product of an evolved human tendency to mistake inanimate objects for living things. But researchers who study small-scale societies suspect that religion has flourished throughout human evolution partly because it deepens individuals' commitment to their communities.

Religion doesn't churn out science-worthy evidence, as Coyne argues. But the author doesn't come to grips with faith's deep evolutionary roots. If religion is irrational, it should have been eradicated through natural selection among Stone Age folk. Coyne's book will irk religious friends and foes of science alike. And that's a fact. — *Bruce Bower*



The Science of TV's the Big Bang Theory
Dave Zobel
ECW PRESS, $17.95

BOOKSHELF

TV show inspires entertaining book

Math, science, history — science writer Dave Zobel unravels the mysteries in *The Science of TV's the Big Bang Theory.*

Some of the show's main characters, five scientists and an engineer, are known for spouting dialog brimming with technical jargon. As Zobel points out, Sheldon, Leonard and the gang sometimes bungle the science a bit. But for the most part, the characters seem to know what they're talking about. Zobel mines the show's scripts for science references and then plunges readers into the nuts and bolts of everything from particle physics to potato electricity.

The result reads like a mash-up of a megafan's guide to *The Big Bang Theory* and David Macaulay's classic science and technology book, *The Way Things Work.* Zobel, a graduate of Caltech (where some of the characters work), has previously written about science for middle school students, and it shows. He romps through playful material (how to make a lasagna battery, and why Mentos can turn a bottle of Diet Coke into a soda geyser), and he's got a knack for nailing tough topics with clever metaphors. To explain the observer effect — why it's impossible to spy on an electron, for example, without affecting its position or momentum — Zobel suggests finding a moth in a dark room by waving a broom around. When you smack the moth, he writes, "you'll send it sprawling... and then you can't say where it is, only where it was."

Zobel begins each chapter with snippets of dialog from the show. It's a cute idea, but sometimes the thread linking *The Big Bang Theory* to chapter topics wears a little thin. In one chapter, he uses a character's mention of a Nintendo 64 game console to launch into the history of data storage.

Bouncing between elementary and advanced subjects can be dizzying. But throughout the book, Zobel lets readers rest. Chapters include sidebars on famous Caltech alumni; these minibiographies give the book heart as well as brains.

Even strangers to the show might enjoy the frequently funny read. But Zobel's book, which sometimes teeters on the edge of schoolish, might be best in short doses — kind of like Sheldon himself. Bazinga! — *Meghan Rosen*

Buy Books Reviews on the *Science News* website include Amazon.com links that generate funds for Society for Science & the Public programs.

Alumni reconnect

When Makayla Gates (above) made her first visit to Washington, D.C., last year as a middle-school participant in the Broadcom MASTERS 2014 science competition run by the Society for Science & the Public, meeting President Barack Obama was a highlight of her experience, she says. Almost a year later, the New Mexico seventh-grader hasn't stopped presenting her project — or rubbing elbows with the political elite.

Gates, whose Broadcom MASTERS project involved making her own acoustic levitator to lift grains of sand with sound waves, recently described her whirlwind of experiences since visiting the nation's capital:

"I loved my trip to Washington, D.C., and, as the only representative from New Mexico in 2014, I have been presenting in other venues. My most recent was at the University of New Mexico Valencia campus as a guest speaker for the New Mexico MESA Winter Youth Leadership Summit," she reports.

In addition to receiving a letter of commendation from New Mexico's Democratic Sen. Martin Heinrich, she had lunch with Republican Gov. Susana Martinez, the first female Hispanic governor of the state. Martinez and Lt. Gov. John Sanchez also gave her a personal tour of Santa Fe's "Roundhouse," the only round state capitol in the United States.

Also during her busy year: "I was invited to become a junior docent at the New Mexico Museum of Natural History and Science for this summer and nominated for participation in the TechTrek program, a STEM program for seventh-grade girls, being held at New Mexico Highlands University."

Partnering with Global STEM Alliance

The Society for Science & the Public will partner with the Global STEM Alliance at the New York Academy of Sciences in 2015 and 2016. The two organizations will work together to develop a diverse pipeline of STEM-capable students, focusing on providing the Society's science competition alumni with opportunities in the Global STEM Alliance's virtual mentoring program. The Society and the New York Academy of Sciences will also explore a possible collaboration to develop a curriculum module focusing on providing students with the skills to design and run research projects.

Advocate Grant recipients selected

In June, the Society for Science & the Public announced the first grant recipients of a pilot program aimed at mentoring students in socioeconomically disadvantaged areas who wish to pursue research in science, technology, engineering and mathematics and take part in science research competitions.

The new SSP Advocate Grant program provides a $3,000 stipend to selected teachers, counselors, mentors or other adults who agree to serve as an advocate for three to five underrepresented students. The recipients will help students who have conducted valid scientific or engineering research projects complete an application to one or more scientific competitions. These advocates will also alert students to possible competitions, assist them in meeting relevant deadlines and support the students in gathering and writing the required elements of the application.

Organizations selected for this pilot year reach an underserved student population that needs additional support preparing their existing science research projects for competition. The Society will distribute a total of nearly $30,000 in advocate grants this year and then evaluate the program's impact on science fair participation rates.

Participants in this pilot program include:

- **Scott Bolen**, Rockdale Magnet School for Science & Technology, Conyers, Ga.
- **Jamie Latham**, North Carolina School for Science and Mathematics, Durham, N.C.
- **Elmer Sanders**, Project SEED, Indianapolis, Ind.
- **Nadia Shapiro**, Stanford RISE, Stanford, Calif.
- **Nedra Starling**, Cleveland Clinic, Cleveland, Ohio
- **Russ Stukel**, TAMS Aspire, Denton, Texas
- **Chuanbing Tang**, Project SEED, Columbia, S.C.
- **Johanna Zapien**, Environmentors, Woodland, Calif.
- **Mark Vondracek**, Evanston Township High School, Evanston, Ill.

For more information about this program, visit **bit.ly/SSP_AdvocateGrant**

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MAY 16, 2015

MAY 30, 2015

SOCIAL MEDIA

Game night for science fans

Science News has reviewed science-based card games, including Evolve and Linkage (*SN: 12/27/14, p. 32*) and, most recently, the game Ion, which challenges players to make chemical compounds (*SN: 5/30/15, p. 29*).

"Thanks a lot, *Science News*. Just ordered Evolve, Linkage and Strain games. Study group for students is about to get more interesting."
@AmandaLynGunn on Twitter

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To edit or not

*A controversial paper about modifying genes in fertilized human eggs raised some serious ethical concerns. **Tina Hesman Saey** covered researchers' arguments for and against this type of genetic engineering in "Editing human germline cells debated" (SN: 5/30/15, p. 16).*

Many readers embraced the idea of making permanent changes to human DNA. "If someone wants to genetically modify themselves or their offspring, why should somebody else's antiquated morals stop them?" asked **nkj123**. "It's only a matter of time before we learn to cure diseases, improve health and increase life span. These experiments will happen, because many of us are not clinging to rigid notions of what it is to be human." In an e-mail, **Justin Cody** urged researchers to proceed with caution when tinkering with egg and sperm cells, but added, "we should be promoting the future of the species aggressively and wringing our hands a lot less."

Not everyone was excited, however. Commenting on *Science News*' website, **Hung Chau** wrote, "I hope we know what we are doing."

Food for thought

*Gut microbes aren't fond of junk food. In "Food fight" (SN: 5/30/15, p. 18), **Laura Beil** described how fatty, salty and sugary foods disturb intestinal ecosystems, leading to inflammation and other health problems.*

"I have seen references to 'processed foods' often in writings on the subjects of diet and nutrition. However, the authors, Ms. Beil included, never give a definition of the term 'processed' — as if everyone knows what that term means," wrote **Calvin Farwell**. "I'm interested in a clear, operational definition — one that I can use to determine whether any particular potential mouthful is 'processed' or not. And I hope that I don't starve to death after reading her definition!"

Beil says that, generally speaking, processed foods are those that are altered from how they occur in nature so that they can be sold in boxes, bottles, jars and cans. Not all are bad. Bagged frozen broccoli counts as processed, for example. "The most heavily processed tend to be the ready-to-eat meals and snack foods. The reason they are often unhealthy is that they contain high amounts of added sugars and fats, and low amounts of fiber. They also tend to contain a lot of additives to extend shelf life and add texture," she says. "I once had a nutritionist tell me a good rule of thumb is that the longer the list of ingredients on the package — often an indication of how processed it is — the less likely it is to be healthy."

Beware the microwave

*In "Source of puzzling cosmic signals found — in the kitchen" (SN: 5/16/15, p. 5), **Christopher Crockett** reported that researchers working with the Parkes telescope in Australia discovered a downside to opening microwaves before they're done cooking.*

"This sounds like something out of a Douglas Adams novel," observed **Ray Andre Haddock** on Facebook. **Robert Fowler** saw the incident as an important lesson in carefully checking research results. When astronomers Arno Penzias and Robert Wilson discovered the cosmic microwave background, they "thought they had found pigeon poop instead of evidence for the Big Bang, and spent weeks cleaning their antenna," he wrote. "In one of his books, Richard Feynman talked about the enormous effort a scientist has to put into making sure experiments are not compromised."

Corrections

"Tiny explosions add up to heat corona" (*SN: 5/30/15, p. 7*) incorrectly said that nanoflares occur on the sun's surface. They occur in the corona.

Part of a sentence was left out on Page 15 of "Snagging clots upgrades stroke care" (*SN: 6/13/15, p. 14*). The full sentence should read: "Downstream, about 2 million neurons die on average each minute until blood flow is restored, Hill says."

JOHN COVEYOU/GENIUS GAMES

A loopy look at sunspots

Tangled nests of magnetic fields burst from sunspots on the solar surface. The spots appear blue and yellow in this false color composite photograph, which was taken in October by NASA's Solar Dynamics Observatory and released in May. The pale streaks trace magnetic field lines, which stretch up to 200,000 kilometers above the surface (black).

In visible light, sunspots look like dark blotches that often expel flares of searing plasma. The orbiting observatory provides a different perspective, aided by the equivalent of ultraviolet goggles and polarized sunglasses. Iron atoms stripped of electrons glow in ultraviolet as they are propelled into the sun's atmosphere, providing a sharp view of the magnetic field lines. Many lines form loops, as seen at the center of the image, that link pairs of sunspots with opposite magnetic polarity.

By watching how these magnetic knots arise and disperse, researchers hope to better understand what drives flares expelled by the sun and other stars. "It's the only star where we can see any of this in detail," says Karel Schrijver, a solar physicist at the Lockheed Martin Solar and Astrophysics Laboratory in Palo Alto, Calif. "It's a great example of what happens elsewhere in the universe." — *Christopher Crockett*

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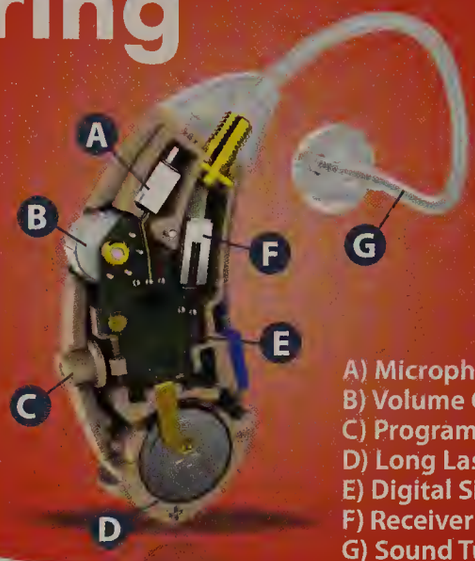

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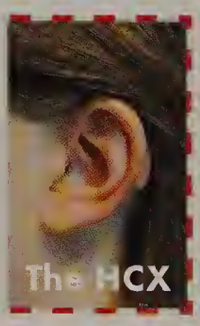

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But When Driving, These Sunglasses May Save Your Life!

Studies by the National Highway Traffic Safety Administration (NHTSA) show that most (74%) of the crashes occurred on clear, sunny days

Drivers' Alert: Driving can expose you to more dangerous glare than any sunny day at the beach can... do you know how to protect yourself?

The sun rises and sets at peak travel periods, during the early morning and afternoon rush hours and many drivers find themselves temporarily blinded while driving directly into the glare of the sun. Deadly accidents are regularly caused by such blinding glare with danger arising from reflected light off another vehicle, the pavement, or even from waxed and oily windshields that can make matters worse. Early morning dew can exacerbate this situation. Yet, motorists struggle on despite being blinded by the sun's glare that can cause countless accidents every year.

Not all sunglasses are created equal.
Protecting your eyes is serious business. With all the fancy fashion frames out there it can be easy to overlook what really matters—the lenses. So we did our research and looked to the very best in optic innovation and technology.

Sometimes it does take a rocket scientist. A NASA rocket scientist.
Conventional sunglasses can blur your vision by exposing your eyes to harmful UV rays, blue light, and reflective glare. They can also darken useful vision-enhancing light. But now, independent research conducted by scientists from NASA's Jet Propulsion Laboratory has brought forth ground-breaking technology to help protect human eyesight from the harmful effects of solar radiation light. This superior lens technology was first discovered when NASA scientists looked to nature for a means to superior eye protection—specifically, by studying the eyes of eagles, known for their extreme visual acuity. This discovery resulted in what is now known as Eagle Eyes®.

Slip on a pair of Eagle Eyes® and everything instantly appears more vivid and sharp. You'll immediately notice that your eyes are more comfortable and relaxed and you'll feel no need to squint. The scientifically designed sunglasses are not just fashion accessories—they are necessary to protect your eyes from those harmful rays produced by the sun during peak driving times.

Navigator™ Black Stainless Steel Sunglasses

Receive the Navigator™ Gold Sunglasses *(a $99 value)* **FREE! just for trying the Navigator™ Black**

Navigator™ Gold Stainless Steel Sunglasses

The Only Sunglass Technology Certified by the Space Foundation for UV and Blue-Light Eye Protection.
Eagle Eyes® features the most advanced eye protection technology ever created. The TriLenium® Lens Technology offers triple-filter polarization to block 99.9% UVA and UVB—plus the added benefit of blue-light eye protection. Eagle Eyes® is the only optic technology that has earned official recognition from the Space Certification Program for this remarkable technology. Now, that's proven science-based protection.

CERTIFIED SPACE TECHNOLOGY spacefoundation.org

Certified EAGLE EYES® was developed from original NASA Optic technology and was recently inducted into the Space Foundation Technology Hall of Fame.

The finest optics:
And buy one, get one FREE!
Eagle Eyes® has the highest customer satisfaction of any item in our 20 year history. We are so excited for you to try the Eagle Eyes® breakthrough technology that we will give you a **second pair of Eagle Eyes® Navigator™ Sunglasses FREE—a $99 value!**

That's two pairs to protect your eyes with the best technology available for less than the price of one pair of traditional sunglasses. You get a pair of Navigators with stainless steel black frames and the other with stainless steel gold, plus two micro-fiber drawstring cleaning pouches are included. Keep one pair in your pocket and one in your car at all times.

Your satisfaction is 100% guaranteed.
If you are not astounded with the Eagle Eyes® technology, enjoying clearer, sharper and more glare-free vision, simply return one pair within 60 days for a full refund of the purchase price. The other pair is yours to keep. No one else has such confidence in their optic technology. Don't leave your eyes in the hands of fashion designers, entrust them to the best scientific minds on earth. Wear your Eagle Eyes® **Navigators** with absolute confidence, knowing your eyes are protected with technology that was born in space for the human race.

Eagle Eyes® Navigator™ Sunglasses ~~$99~~†
Offer Code Price **$49** + S&P **Save $50**
***PLUS* receive the Navigator™ Gold absolutely FREE!—2 pairs for the price of one!**

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